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ORIGINAL ARTICLES.

I.—On a Reconstructed Skeleton of *Diprotodon* in the British Museum (Natural History).

By Arthur Smith Woodward, LL.D., F.R.S.

(PLATE XV.)

FOR many years palæontologists have anxiously awaited the reconstruction of the complete skeleton of *Diprotodon* by Dr. E. C. Stirling, Mr. Zietz, and their colleagues in the South Australian Museum. In 1893, when it was announced that numerous nearly complete skeletons of this gigantic extinct marsupial had been discovered in the arid interior of South Australia,[1] it was hoped that all details of its osteology would soon be known; but the difficulties of excavating and transporting the fragile bones, and the skill and patience needed in preparing them after they reached the Museum in Adelaide, were so considerable as to necessitate long delay in obtaining satisfactory results. At last, however, a mounted reproduction of a skeleton has been completed in plaster, and Dr. Stirling has published three excellent photographs of the specimen in the "Report of the Board of Governors of the Public Library, Museum, and Art Gallery of South Australia for 1905–6," lately received. The Governors of the South Australian Museum have given a copy of this restoration to the University of Cambridge, where it is now mounted in the Museum of Zoology. They have also generously presented to the British Museum a set of actual limb-bones and caudal vertebræ, with sufficient plaster casts to complete the reconstructed skeleton which is shown in Plate XV. As this restoration differs in some respects from that in Adelaide, it appears to need a brief explanation.

The head and the presacral part of the vertebral column in the British Museum specimen are exact copies in plaster of the reconstruction in Adelaide. The skull, unfortunately, is only a restored model, all the original specimens from Lake Callabonna being too much crushed for satisfactory use. The precise shape of the skull of *Diprotodon*, in fact, still remains to be discovered; for a recent careful examination of the specimen from Queensland

[1] E. C. Stirling: Proc. Zool. Soc., 1893, p. 173; also, "The Recent Discovery of Fossil Remains at Lake Callabonna, South Australia": *Nature*, vol. i. (1894), pp. 184–188, 206–211.

described by Owen,[1] has proved that the whole of its middle part is a hypothetical restoration in plaster. In the latter specimen all the brain-case is wanting, except the occipital plate; and now that the added plaster has been removed, a correct adjustment of the zygomatic arches shows that the total length of the skull is from four to five inches shorter than it was supposed to be by Owen. The newly-determined length agrees with that of the South Australian model, but in other respects the actual portions of skull preserved differ considerably from the corresponding parts of the model. This model is altogether wider and stouter than Owen's original specimen from Queensland, with a much deeper zygomatic arch. Its mastoid processes are made larger; the occipital plate is higher at the sides, the lambdoidal crest not sloping so much from the apex; and above the foramen magnum there should be a well-marked depression, which was partly filled with plaster in the Queensland specimen when Owen prepared his description. At least, if there is justification for these features of the model in the Callabonna specimens, the South Australian animal is specifically distinct from *Diprotodon australis*. The seven cervical vertebræ agree well with those from Queensland in the British Museum. There are fourteen thoracic and five lumbar vertebræ, all with the neural arches much less elevated than those shown in Owen's original-restored drawing of the animal. The centra of the posterior dorsal and lumbar vertebræ are slightly wedge-shaped, and readily form the curve in which they are now mounted.

The pelvis and sacrum in the British Museum skeleton are a copy in plaster of a well-preserved specimen from Queensland, with the anterior expansion of each ilium restored from the photograph of a pelvis found in the Wellington Caves, New South Wales (probably now in the Australian Museum, Sydney.) Two Queensland specimens in the British Museum and the original of the photograph just mentioned exhibit only two sacral vertebræ fused with the pelvis, as already described by Owen.[2] We have therefore ventured to regard the sacral vertebræ as normally two in number, and have not reconstructed the additional two vertebræ to conform to the South Australian restoration, which has a sacrum of four vertebræ fused with the pelvis. The caudal vertebræ, actual specimens from Lake Callabonna, are nineteen in number.

In the limbs of the British Museum skeleton, the scapulæ are plaster casts of two specimens from Queensland, while the fore and hind feet of the right side are plaster casts of feet in the South Australian Museum. All the other parts are actual bones carefully selected by Dr. Stirling from his large collection from Lake Callabonna. The humerus and femur are about equal in length, the first being slightly longer, the second slightly shorter than the corresponding bones in Dr. Stirling's restoration. The length of the scapula bears the same relation to that of the humerus as in the latter restoration. The feet exhibit well the diminutive digits, and conform to the

[1] R. Owen, "On the Fossil Mammals of Australia.—Part III: *Diprotodon australis*, Owen": Phil. Trans., 1870, p. 521, pl. xxxv.

[2] Loc. cit., 1870, p. 554, pl. xlvii.

admirable description already published by Dr. Stirling and Mr. Zietz.[1] As pointed out by M. Dollo,[2] the reduced and opposable inner digit of the hind foot suggests that the immediate ancestors of *Diprotodon* were arboreal in habit.

The slight discrepancy in the relative length of the limbs in the two reconstructed skeletons obviously causes a considerable difference in their general proportions and appearance. The curvature of the back and the relatively high forequarters in the British Museum specimen make it approximate more closely in attitude to Owen's original tentative restoration[3] than to the plaster cast as mounted in Adelaide.[4] In both cases the limb-bones seem to have been selected from several individuals, and Dr. Stirling and Mr. Zietz have not yet published their measurements of the complete skeletons as they lay on the ground before removal.[4] The final decision as to the exact proportions of *Diprotodon* must depend on these and other measurements of associated bones, for it is evident that individuals vary in size. While expressing our grateful appreciation of the valuable contributions which Dr. Stirling and Mr. Zietz have already made to our knowledge of this remarkable extinct Australian quadruped, we therefore venture to hope that their memoir on the whole skeleton will now soon be ready for publication.

The original photograph of the skeleton of *Diprotodon*, used in preparing Plate XV, was taken by Sir J. Benjamin Stone, M.P., F.G.S., on the 14th June last, in the Hall of the British Museum of Natural History, Cromwell Road, and by his kind permission is here reproduced for the first time.

II.—The Cretaceous Rocks of Natal and Zululand and their Cephalopod Fauna.

By G. C. Crick, A.R.S.M., F.G.S., of the British Museum (Natural History).

(WITH A PAGE MAP.)

IN the "Third and Final Report of the Geological Survey of Natal and Zululand" that has just been published the Cretaceous rocks and their fauna receive considerable attention: Mr. William Anderson, F.G.S., the Government Geologist, gives an excellent summary (pp. 47–64) of all the information he had been able to obtain respecting the Cretaceous rocks of Natal and Zululand, and there are two contributions on the fauna of some Cretaceous deposits in Zululand, one by Mr. R. Etheridge and the other by the present writer. Before referring particularly to the Cephalopod fauna of the Cretaceous rocks of Natal and Zululand it may be of interest to give a brief sketch of the distribution of these rocks as recorded by Mr. Anderson.

[1] E. C. Stirling & A. H. C. Zietz, "Description of the Manus and Pes of *Diprotodon australis*, Owen": Mem. Roy. Soc. S. Australia, vol. i (1899), pp. 1–40, pls. i–xviii. See also Geol. Mag., 1900, p. 28.

[2] L. Dollo, "Le Pied du *Diprotodon* et l'Origine Arboricole des Marsupiaux": Bull. Sci. France et Belg., vol. xxxiii (1900), pp. 278–283.

[3] Loc. cit., 1870, pl. i.

[4] See the interesting photograph in Mem. Roy. Soc. S. Australia, vol. i, pl. a, fig. 2.

More than fifty years ago the presence of rocks of Cretaceous age was recorded on the coast of Pondoland,[1] to the south of Natal, and in geological literature these are not infrequently referred to as Cretaceous rocks of Natal, but the first record of the occurrence of Cretaceous deposits in Natal and Zululand was made in 1871 by Mr. C. L. Griesbach in his paper "On the Geology of Natal in South Africa," who, when describing more especially the Cretaceous deposits of Pondoland, records the existence in Natal of Cretaceous outcrops "on the Impenyati River and at some of the more southern rivulets which run into the sea between the boundary of Natal and the St. John's River (Umzimvooboo)." "The same," he goes on to say, "are also recognised in the bed of a small stream, running into the St. Lucia Bay, in the Zulu country." Shortly afterwards Mr. St. V. W. Erskine recorded the occurrence all the way up from St. Lucia Bay to the Zambesi River of limestones and arenaceous beds; these Mr. Anderson considers to be of Upper Cretaceous age, excepting perhaps some deposits in isolated positions that are probably of Tertiary age.

In Natal proper there are only two localities in which Cretaceous rocks are known to occur. The more southerly of these is on the south-east coast, and extends between high and low water marks northwards from the mouth of the Umpenyati River (about nine or ten miles from the Umtamvuna River, which forms the southern boundary of Natal) to within half a mile of the mouth of the Umhlengeni River, a distance of about a mile and a half. The other locality is at Durban, between 80 and 90 miles further north, where the rocks were met with in a boring at the Bluff.

In Zululand the most southerly point at which Cretaceous rocks are known to occur is on the north side of the Umhlatuzi Lagoon, close to the coast, where they have been found in borings, but Mr. Anderson thinks it is probable that they are also present under the most superficial deposits nearly as far south as the Umlalaaz River, which is some twenty miles farther south, i.e. about five or six miles south of Port Durnford, although no deposits of this age have actually been seen on the coast between the Umhlatuzi Lagoon and Durban in Natal, a distance of about one hundred miles.

Of the surface outcrops of the Cretaceous rocks in Zululand the most southerly is at Umkwelane Hill, near Lake Isitesa, on the south side of the Umfolosi River. It is entirely confined to the hill. This deposit, of which the fauna has been described by Mr. R. Etheridge in the "Second Report of the Geological Survey of Natal and Zululand," 1904, is some 20 miles north of the Umhlatuzi Lagoon, and about 15 miles from the coast. According to Mr. Anderson the limestone in the two localities is almost identical petrologically, whilst some of the fossils obtained from the bores at the Umhlatuzi Lagoon were identifiable with some of those occurring at the Umkwelane Hill. At the common exit of the Umfolosi River and the drainage of St. Lucia Lake into the sea at St. Lucia Bay, there are calcareous

[1] R. J. Garden, "Notice of some Cretaceous Rocks near Natal, South Africa": Quart. Journ. Geol. Soc., vol. xi (1855), pp. 453–454. W. H. Baily, "Descriptions of some Cretaceous Fossils from South Africa, collected by Captain Garden of the 45th Regiment": ibid., vol. xi (1855), pp. 454–465, pls. xi, xii, xiii.

sandstones which hitherto have proved unfossiliferous; these, and similar rocks occurring further to the north at Cape Vidal, Mr. Anderson is inclined to think will prove to be of Tertiary age. At many points round the edges of St. Lucia Lake and False Bay, Mr. Anderson observed low outcrops of horizontally bedded strata, consisting chiefly of calcareous marls and sandstones. The few fragmentary fossils obtained from these Mr. Etheridge was inclined to refer rather to the Tertiary than to the Cretaceous system. Near the northern end of False Bay the western boundary of the littoral is formed by the Rhyolite of the Lebombo Range, which extends thence northward past the Portuguese border; between False Bay and the western boundary of the littoral there are several Cretaceous outcrops which have yielded characteristic Cretaceous fossils.

As it is principally with the Cephalopod fauna of these several outcrops that the present communication deals, they may be best described in Mr. Anderson's own words.

"The Mamuan Creek,[1] which joins the Umsinene River before its entrance into False Bay, has three tributaries, over each of which the northern wagon-track passes. Near each of the three crossings outcrops of Cretaceous rocks occur containing fossils. The fossils from the outcrops at the most southerly tributary are described by Mr. R. Etheridge as Part II of the 'Cretaceous Fossils of Natal,' in the present Report of the Geological Survey (p. 67), under the title of the 'Umsinene River Deposit.' This name does not describe accurately the position of the deposit from which the fossils that are described came, but owing to the fact that there are four fossiliferous deposits all in a small portion of the Mamuan Creek basin, the name 'Umsinene Deposit' refers to the deposit occurring immediately to the north of the crossing of the most southerly tributary of the Mamuan Creek. The others are at the crossing of the middle and the northern tributary, to the east of Crossly's store, while the fourth locality is near, but to the west of, the junction of the Mamuan Creek with the Umsinene River.

"The outcrop of the 'Umsinene deposit' is of limited extent and is exposed chiefly in the bed of the southernmost tributary of the Mamuan Creek, and on the rising ground to the north of it, and it again appears where the wagon-track crosses the next spruit to the north. The rock is a calcareous, argillaceous, fine-grained sandstone of a brownish colour, with fossils scattered sparingly through it . . . .

"The next deposit occurs on the middle tributary of the Mamuan Creek to the north. Where the wagon-track crosses this creek the rock is Rhyolite, which persists right to the source of the creek. Below the crossing the right-hand bank is entirely of Rhyolite, while on the left-hand bank a small outcrop of fossiliferous Cretaceous rocks occurs."

"The fossils in this deposit," says Mr. Anderson, "are described by Mr. G. C. Crick . . . . in this Report under the title of 'The South Mamuan Creek Deposit.'".

[1] This name is not given in any of the maps accompanying Mr. Anderson's reports, and has therefore been omitted in the map which is reproduced herewith. It appears to be the stream, flowing from the north, which joins the Umsinene River just before its entrance into False Bay.

"At intervals," Mr. Anderson continues, "Cretaceous beds crop out in the bed of the northern tributary of the Manuan Creek as far west as the point where the Mkuzi[1] River track crosses the creek, at the foot of the hill to the east of Crossly's store . . . . . The fossils from this deposit have not yet been described."

"The other fossiliferous Cretaceous deposits," writes Mr. Anderson, "which I have been able to visit and make collections from are situated near the junction of the Manuan and the Umsinene Rivers. The exposure shows a thicker series of beds than in any other locality from which I have collected. There are from 70 to 100 feet of strata exposed, chiefly calcareous sandy shales and sandstones, the whole being capped by a very hard calcareous sandstone full of broken shells. The beds are exposed almost continuously where the bank is precipitous. They are exceedingly prolific in fossils, chiefly Mollusca, Cephalopoda, and Gasteropoda. The Cephalopoda are extremely abundant, and range in size from forms of half an inch to over a yard in diameter. The fossils weather from the shales in a perfect condition, but from long exposure on the surface to the atmosphere, rains, and bush fires, they are largely composed of casts. Some good specimens, however, were obtained. These are described by Mr. G. C. Crick, of the British Museum, in this Report, under the title of the 'North End of False Bay Deposit.'"

According to Mr. Anderson there are many other localities in the neighbourhood of False Bay where the Cretaceous rocks are exposed, but he had not been able to make collections from them. The most northerly point from which he had obtained fossils was to the east of Crossly's store, near the southern end of the Lebombo Range, but he knows of other outcrops of fossiliferous rocks still further north.

Having given this brief sketch of the distribution of the Cretaceous rocks of Natal and Zululand, attention may now be directed to the Cephalopod fauna of these deposits.

It may first be mentioned that the fauna of the Cretaceous rocks of Pondoland (known also as the Umtamfuna or Umzamba Beds), that was first described by Baily in 1855, has quite recently been the subject of a memoir, in the Annals of the South African Museum (vol. iv, pt. 7, 1906), by Mr. H. Woods, who concludes that the whole of these beds are of Campanian (Upper Senonian) age.

Of the two localities in Natal proper at which Cretaceous deposits are known to be present, the beds at the one which occurs on the coast between high and low water marks, between the mouth of the Umpenyati River and the mouth of the Umhlengeni River, agree, according to Mr. Anderson, both petrologically and palæontologically with the beds on the coast of Pondoland to the south. As Mr. Anderson points out, the lower portion of the series is much more fossiliferous than the upper portion, though it is not possible to divide the series into recognisable subdivisions. From the list of the Cephalopoda given by Mr. Anderson (Third Report, pp. 50–51), there can be no doubt about the identification of these strata with the Umtamfuna

[1] Spelt 'Umkusi' on the map.

or Umzamba Beds.[1] At the mouth of the Boboi River, between the Umtamvuna and Umpenyati Rivers, there is a small outcrop of horizontal unfossiliferous sedimentary rocks that Mr. Anderson thinks is probably a small outlier of the same series of rocks.

In the boring at the Bluff, Durban, only fragmentary fossils were obtained; no Cephalopods are quoted. In his work on the "Pseudoceratites of the Cretaceous" (Mon. U.S. Geol. Surv., vol. xliv, 1903), Professor Hyatt described and figured (p. 86, pl. xi, figs. 2–6) as *Eulophoceras natalense*, gen. et sp. nov., a single specimen, the locality of which he gave as Port Natal, South Africa. Mr. Anderson doubts the locality given by Hyatt, and says (p. 50): "As the presence of Cretaceous rocks at Port Natal has only recently been made known, and as no outcrops of them occur on the present land surface, it is unlikely to have been thrown up from the possible outcrop on the sea-floor, and I think it is more than probable that the actual locality from which it came was not Port Natal, but probably it was a specimen which had been brought to the Port, either from the Upper Cretaceous deposits at the mouth of the Umpenyati River, on the south-east coast of Natal, or from the Cretaceous deposits on the coast of Pondoland." This opinion is strengthened by the occurrence of the same genus and possibly the same species among the fossils described by Mr. Woods from Pondoland.

In Zululand the most southerly outcrop of Cretaceous rocks from which fossils have been obtained is at Umkwelane Hill, near Lake Isitesa, south of the Umfolosi River. The fossils, which were described by Mr. R. Etheridge in the "Second Report of the Geological Survey of Natal and Zululand," 1904, included a few Cephalopods, viz., two new species of *Placenticeras*, an undetermined species doubtfully referred to the genus *Crenoceras*, a fragment of *Hamites*, and a piece of *Baculites*. Comparing the whole fauna with that of the Umtamvuna (or Umzamba) Beds in Pondoland, Mr. Etheridge says (Second Report, 1904, p. 93): "*Pazosia Gardeni*, Baily, sp., has not been observed in the present collection, nor any of the Ammonites mentioned as occurring in Griesbach's stratum *c*, nor *Teredo*-bored wood as in *c* of the same author. The fauna of the Umkwelane Hill Deposit consists, with few exceptions, of bivalves and univalves, like that of Griesbach's stratum *b*, and some of the species are identical with those met with in the latter. There appears to be a close connection between the fossils of the two beds: possibly they may be actually on the same horizon." Mr. Woods considers the Umkwelane Hill Deposit to be of the same age as the Cretaceous rocks of Pondoland, and this opinion is strengthened by the occurrence at Umkwelane Hill of an ammonite which the present writer refers (Third Report, 1907, p. 228, pl. xv, figs. 9, 9*a*) to the genus *Mortoniceras*, and regards as being related to *Mortoniceras Soutani* and *M. Stangeri* from the Cretaceous rocks of Pondoland.

Although this is the most southerly outcrop of the Cretaceous beds in Zululand, they have been met with some 20 miles further south, in bores which were sunk to the north of the Umhlatuzi Lagoon close

[1] The present writer has also recognized (Third Report, 1907, p. 250) from the Umpenyati strata an example of *Schlumbachia inflata*, a species originally described from the Pondoland deposits.

to the mouth of the Umhlatuzi River, as an arenaceous limestone full of fossils, which, according to Mr. Anderson, were identifiable with some of those occurring in the limestone at Umkwelane Hill.

Most of the outcrops of Cretaceous rocks in Zululand, from which Mr. Anderson collected fossils, are in the neighbourhood of the north end of False Bay and St. Lucia Lake, some 40 miles north of Umkwelane Hill. The fossils from several of these outcrops have been described in the "Third and Final Report," which has just been issued.

Some of these fossils are described by Mr. R. Etheridge under the title of the "Umsinene River Deposit"; whilst the present writer has described "The Cephalopoda from the North End of False Bay, Zululand," and "The Cephalopoda from the Tributaries of the Mamuan Creek, Zululand."

As already stated, the Mamuan Creek, which joins the Umsinene River before its entrance into False Bay, has three tributaries, over each of which the wagon-track passes. It was, Mr. Anderson states, from the deposit occurring immediately to the north of the crossing of the most southerly tributary[1] of the Mamuan Creek that the fossils described by Mr. Etheridge under the title of the "Umsinene River Deposit" were obtained. Referring to this fauna Mr. Etheridge says: "Only one species can be said to be actually identical with the Umkwelane Hill fauna, viz., *Alaria* (?) *Bailyi*, Eth. fil., but as the general facies of the Umsinene fossils resembles that of the Umkwelane Hill bed, I am induced to regard them simply as horizons in one and the same geological series." Mr. Etheridge goes on to say: "If my determinations of these very fragmentary fossils are correct, we find in the Umsinene bed four Uitenhage forms" . . . . and then, referring to the Cephalopoda, which include only a few forms, viz., *Douvilleiceras* (?) *nodosum*, n.sp., *Douvilleiceras* sp., *Desmoceras* sp., and *Hamites* sp., remarks that "as in the case of the Umkwelane Hill fauna there is an entire absence of those species recorded from the Umtafuna fauna by Griesbach."

Of the Cephalopod faunas described by the present writer in the Report, that from the deposit at the north end of False Bay, and near the junction of the Mamuan and Umsinene Rivers, where from 70 to 100 feet of strata are exposed, is a particularly rich one, the forms ranging in size, according to Mr. Anderson's statement, from half an inch to more than a yard in diameter; it includes the genera *Phylloceras*, *Gaudryceras*, *Tetragonites*, *Turrilites*, *Baculites*, *Kossmaticeras* (?), *Forbesiceras*, *Acanthoceras*, *Desmoceras*, *Puzosia*, and *Nautilus*, with many new forms, the number of forms of *Acanthoceras* being particularly noteworthy.

Compared with the fauna of the nearest outcrop, viz., that described under the title of "The Umsinene River Deposit, Zululand," the False Bay deposit has not yielded any specimen resembling either the Hamite or the examples doubtfully referred to the genus *Douvilleiceras*, but the specimen recorded from the Umsinene River

[1] This tributary is not named in the map accompanying this paper; from Mr. Anderson's description it appears to be the stream which is named the Unyan River in the Geological Sketch-maps of Zululand issued with the First and Second Reports respectively.

deposit as *Desmoceras* sp. resembles some of the forms which are described from the False Bay deposit as *Puzosia*, although it does not actually agree with any one of them. The fauna of this deposit does not include any of the forms which have been recognized in the Umkwelane Hill deposit, some 40 miles to the south; nor any of those recorded from the Umpenyati strata still further south; nor any of the species described from the Cretaceous rocks in Pondoland. The relation of the False Bay fauna to that of the Mannan Creek deposits, which are only at a comparatively short distance, is referred to below.

To the north of Zululand Professor Kilian[1] has recorded the occurrence of an Aptian fauna at Delagoa Bay, but the False Bay fauna contains no Aptian forms. Still further to the north, from rocks near the mouth of the Conducia River, which debouches into the Indian Ocean a little north of Mozambique, M. Paul Choffat[2] has described a fauna composed principally of Cephalopods, the age of which he regards as from Vraconnian to Cenomanian. M. Lemoine[3] considers them to be of Cenomanian age. Some of the forms closely resemble some of those from the False Bay deposit.

The fauna from the north end of False Bay is undoubtedly of Cenomanian age.

The Cenomanian fauna which has been recorded,[4] and is being described,[5] from the north of Madagascar, presents a striking resemblance to the False Bay fauna. Several of the species which, up to the present, have been characterized, are represented in the False Bay deposit, and doubtless when the whole fauna has been described the similarity between the two faunas will be very apparent.

The False Bay fauna also shows great analogy to that of the Utatúr Group in the Trichinopoli district of Southern India, particularly with its Middle and Lower portions. According to Dr. Kossmat,[6] the equivalents of this group are as follows:—Upper Utatúr = Lower Turonian; Middle Utatúr = Upper and Middle Cenomanian; Lower Utatúr = Lower Cenomanian (Vraconnian).

The False Bay fauna also exhibits analogy to that of the Cenomanian of Europe.

Other Cephalopoda also described by the present writer in the same Report are recorded under the title "The Cephalopoda from

[1] W. Kilian: "Sur quelques gisements de l'étage aptien." Bull. Soc. géol. France, sér. iv, ii (1902), p. 358; "Sur la présence de l'étage Aptien dans le Sud-Est de l'Afrique," Comptes rendus, cxxxv, No. 1, 7 Juli, 1902, pp. 68–71; "Ueber Aptien in Südafrika," Centralbl. für Mineral. Geol. und Paläont., No. 15 (August 6, 1902), pp. 465–8.

[2] Paul Choffat: "Contributions à la connaissance géologique des colonies portugaises d'Afrique: I. Le Crétacique de Conducia," 1903. (Com. Serv. géol. Portugal.)

[3] P. Lemoine: "Études géologiques dans le nord de Madagascar," 1906, p. 306.

[4] For references see P. Lemoine: "Études géologiques dans le nord de Madagascar," 1906.

[5] M. Boule, P. Lemoine, and A. Thévenin: Ann. de Paléont., i.

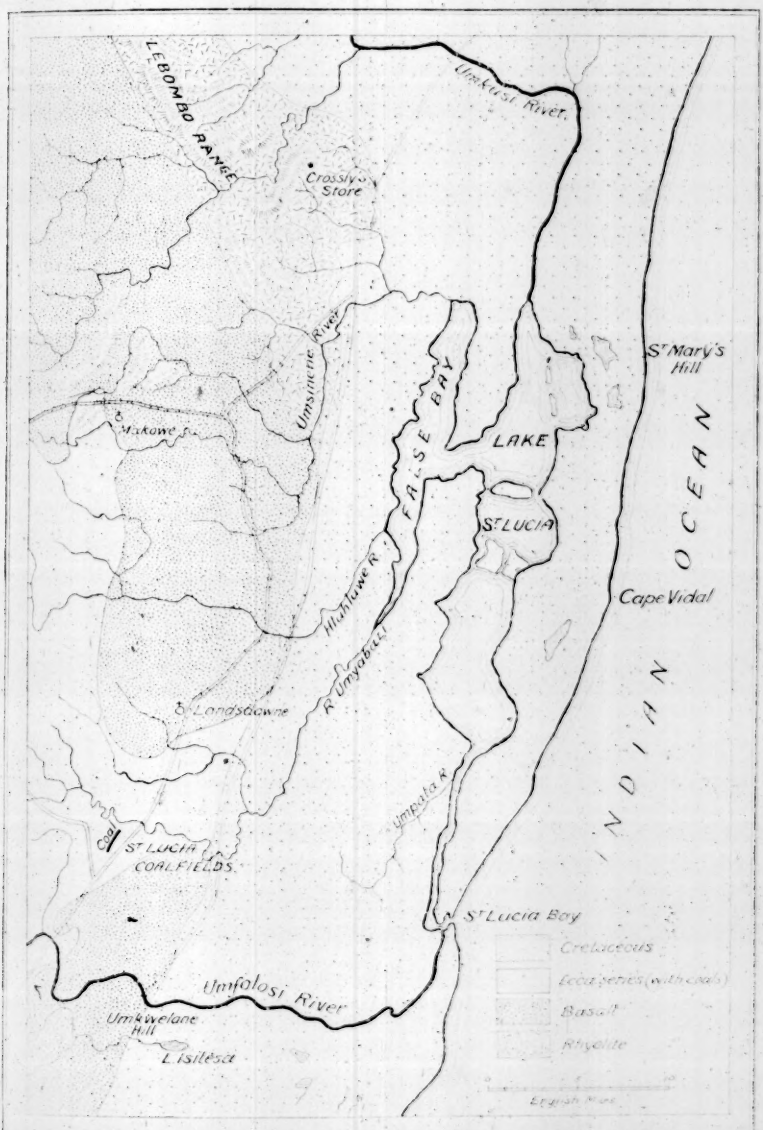
[6] F. Kossmat, "Die Entwickelung der südindischen Kreideformation, etc.": Jahrb. d. k.k. geol. Reichsanst., Wien, Bd. xliv (1894), Heft. iii and iv; April, 1895, p. 699; and Records Geol. Surv. India, xxviii, pt. 2 (May, 1895), p. 40.

the Tributaries of the Manuan Creek, Zululand." Most of these, principally Nautili, were stated to have come from the "South Branch, Manuan Creek," a few only being labelled "Crossing Middle Tributary, Manuan Creek." It would appear, however, from Mr. Anderson's remarks in the Report which has just been issued (p. 59) that all the specimens which the present writer has described from the "Tributaries of the Manuan Creek" were obtained from the deposit which has been referred to above[1] as occurring on the left-hand bank of the middle tributary. "The outcrop," says Mr. Anderson, "is a very small outlier, exposed on the slope of the northern bank of the creek, and is completely isolated on the Rhyolite. This exposure passes along the north side of the creek for a distance of a few hundred yards. The strata, as exposed in the cliff, which is about 20 feet in height, consists of a dirty grey-brown calcareous sandstone, which contains the chief specimens of the Cephalopoda, both Ammonites and Nautili. Below this, about 15 feet of shales and marls, chiefly containing Mollusca and other forms." Since the matrix of the specimens marked "South Branch, Manuan Creek," agrees with Mr. Anderson's description of the upper part of this deposit, it would seem that they were obtained from this portion, whilst the few fossils labelled "Crossing Middle Tributary, Manuan Creek," may have been obtained from the lower portion consisting of shales and marls. At any rate, the few specimens labelled "Crossing Middle Tributary, Manuan Creek," seem to indicate a somewhat lower horizon than the fossils labelled "South Branch, Manuan Creek." The fossils from this deposit are as a rule fragmentary and very imperfectly preserved. The general facies of this fauna differs somewhat from that of the False Bay fauna; the latter is characterized by an abundance of forms of *Acanthoceras*, the fauna of the upper part of this deposit by the prevalence of Nautili. Whether the fauna of the upper part of this deposit is simply another facies of that found at False Bay is not quite certain; it may be, or it may possibly indicate, a somewhat higher horizon, but the specimens labelled "Middle Tributary, Manuan Creek," that we believe to be from the lower portion of this outcrop, seem to show the existence in this deposit either of the lower portion of the beds which are exposed at False Bay, or even of a slightly lower horizon.

A review of the faunas obtained from the several exposures of Cretaceous rocks in Natal and Zululand seems to confirm Mr. Anderson's statements (Third Report, pp. 48–49): (1) that "all the fossils obtained from the various localities where exposures of these rocks have proved fossiliferous, in Natal and Zululand, belong to the Upper portion of the Cretaceous System"; and (2) that "so far as our present knowledge goes, no representatives of the Lower Cretaceous have yet been proved in Natal or Zululand." The beds near the mouth of the Umpenyati River in Natal are evidently of the same age as the Pondoland deposits, whilst the beds which are found in the southern part of Zululand, at Umkwelane Hill and in the boring north of the Umhlatuzi lagoon, are probably also of the same age. Further north, however, near the north end of False Bay, rocks of Cenomanian age occur, and to the west of these, in the neighbourhood of the Manuan

[1] See *ante*, p. 346.

Creek and its tributaries, beds of the same age, passing down possibly into rocks of Upper Albian age, are probably also present. The occurrence here of Cretaceous beds of an age younger than Cenomanian is somewhat doubtful.



Geological Sketch-map of part of Zululand. After W. Anderson.

III.—Glaciation and Physiography in the North-East of Anglesey.

By Edward Greeney, F.G.S.

(WITH A SKETCH-MAP.)

THE general direction of glaciation in the north-east of Anglesey is from about N.N.E. to S.S.W., with local variations of a few degrees on either side.[1] These are but of minor importance, the general trend being remarkably steady, so much so as even to indicate beforehand the existence and approximate position of unknown occurrences of certain rocks by thin trains of boulders.

When surveying the country about Llanerchymedd and Rhosgoch, I was, therefore, much perplexed by finding large numbers of fragments of Carboniferous Limestone. For these could not have invaded that district if carried from the known exposures of that rock by ice moving in the direction mentioned: as will be evident from a glance at the annexed sketch-map (p. 349).

I even made enquiries from leading farmers whether it was possible that they might have been brought in imperfectly burnt lime used in agriculture in former times; for none had then been found in the boulder-clay, but only upon the surface. The farmers thought this was possible, and for a while I rested in that view. But fragments of the local Old Red Sandstone then turned up, and last summer, in particular, a mass of it no less than 10 feet long, lying on the north-west shore of Dulas Inlet, which was even there a little too much to the north for the prevalent trend. These, at any rate, were not brought artificially. Besides, the Boulder-clay at the mouth of Dulas Inlet is decidedly red. Now, at Porth Gwichiaid, some distance to the north, there is an excellent section in Boulder-clay, and in this I found unmistakable boulders of Carboniferous Limestone with crinoids, beautifully water-worn, besides many others of sandstone and conglomerate of Carboniferous type. Here, at any rate, there could be no doubt.[2] From no visible outcrop could these boulders have been derived, and it is evident they have come from out of the sea.

If, now, we produce the base-line of the Carboniferous Limestone from where it reaches the coast to the little island in Dulas Bay where the tower of shipwreck-refuge is, we shall see that it is curving somewhat to the north and west, instead of running out on a north-east strike as might have been expected; and if we further produce this line, following the curve thus indicated, we shall find that it sweeps round the north-east of Anglesey at no great distance from the land.

This, then, is the source of the boulders of Port Gwichiaid, and this is the source of the much more numerous boulders that are scattered far and wide over the country about Rhosgoch and Llanerchymedd.

[1] As the end of my work in Anglesey is now within sight I may perhaps say that this and other short papers already published are portions of continuous glacial work in the island. Since coming there some twelve years ago I have put the drift and allied information upon the six-inch maps as well as the "solid" geology, so from these a connected account of the glaciation of the island can be given.

[2] There seems to be an older set of striæ at one place running W.S.W., but it is under high land, and is evidently a local deflection.

[3] As large tracts of that country are above the 600 feet contour, we have here an case of those uplifts of boulders of which I have now on record a good number examples in the island.

Further, on examination of the Porth Gwichiaid Boulder-clay, as well as that at Dulas Inlet, I found that the rest of its contents consisted of rocks foreign to Anglesey, with some of local Ordovician type, but that fragments from the Schistose Complex were rare or almost absent. The Schistose Complex cannot therefore extend to any distance beneath the sea to the north-east; indeed, the limit must coincide very nearly with the present coastline.

Now, on reference to the sketch-map, it will be seen that the submarine curve we were considering runs as nearly as possible parallel to that of the coast itself as far as Point Lynas. To the east and north-east, therefore, it is clear that the existing land of Anglesey coincides very nearly with the limits of the old Crystalline and Ordovician Complex, and that the Irish Sea in that direction is floored by Carboniferous and probably also by later rocks.

Sketch-map of North-East Anglesey. The arrows indicate the direction of glaciation. Scale, two miles to an inch.

IV.—"How Long Ago" in Geology.

By Edward A. Martin, F.G.S.

ONE is frequently asked the question, how long ago is it since certain geological phenomena took place in which the questioner is interested for the time being. How long ago were the great coal-beds deposited, or how long ago is it since the chalk was formed at the bottom of the sea?

Now, dates in geological history cannot be given with any degree of certainty. The amount of conjecture in proportion to the amount of fact must be very large indeed; yet even a rough estimate is not without its value, since it may give an idea of the really comparatively short space of time in geological history during which some of the best-known formations were laid down.

Geologists will for a long time differ amongst themselves as to what term of years has elapsed since a solid crust had formed on the surface of our globe, when life as we know it had first begun to be, and when denudation and all that it means had commenced to operate, and in embossing upon the surface of the earth the scenery as we now see it. Things have changed since geologists were asked to limit themselves to 20 millions of years as the period during which all the sedimentary formations were laid down. Professor Huxley's willingness to confine himself to 100 millions of years is not altogether concurred in, now that the discovery of the great energy lying dormant in the various radio-active bodies has shown the possibility of a much greater age being assigned to the sun as a heating luminary over and above that hitherto supposed. I am justified from many points of view in assuming that a solid crust had formed about 250 million years ago, that strata have formed at an average rate of one foot in 700 years, and that the older the rocks the more the strata have been compressed into thinner layers. We must also not only consider in our discussion the number of years which known strata took to form, but the years which are represented by the great gaps between the formations when no deposition was taking place but when great changes were taking place in the evolution of life.

Adopting Sollas' measurements of known strata, and placing against each formation the number of years which it approximately represents, we shall have the following table (see p. 351). For all strata below and including the Devonian I have allowed an addition of 50 per cent. for compression subsequent to deposition. For the Carboniferous, Permian, and Triassic I have added 25 per cent. for the same reason, and from the Jurassic to the Oligocene 10 per cent. For deposits between the Miocene to the Recent inclusive I have left the thicknesses as estimated by Sollas, since the rate of deposition may in some portions have been less than the estimated rate already mentioned, and in other parts there may have been compression as in older formations. The relative proportion of each formation to the rest will be found in column three.

We shall find from this table that approximately the great Coal age came to a close 70,495,000 years ago, and the Chalk age (Cretaceous) 31,680,000 years ago. It will also be seen that an enormous period had elapsed before the earliest formation commenced to be laid down in which fossil life is decipherable, viz. Cambrian. The earlier great American formations, included in which is the older-named Laurentian, show a space of time of 86,100,000 years.

It is interesting to note the years which have been necessary according to this table to evolve the various forms of life. The evolution of the trilobites of the Cambrian was accomplished in about 86 millions of years. The six-feet-long Crustaceans and mudfish of

the Old Red Sandstone took 136,560,000 years to arrive upon the scene, and the small reptiles of the coal era were the outcome of 159,000,000 years. The winged reptiles of Jurassic times took 21,875,000 years more to be evolved, whilst the small marsupial mammals of the same period were followed in another 16,940,000 years by the great mammals of Eocene times. And then came the crowning of the evolutionary movement by the appearance of the human species in Pliocene times.[1]

System.	Actual Thickness in Feet.	Before Compression.	Relative Proportion.	Years.
Pleistocene and Recent...	4,000	4,000	4	2,800,000
Pliocene	5,000	5,000	5	3,500,000
Miocene	9,000	9,000	9	6,300,000
Oligocene	12,000	13,200	13·2	9,340,000
Eocene	12,000	13,200	13·2	9,340,000
Cretaceous	14,000	15,400	15·4	10,780,000
Jurassic	8,000	8,800	8·8	6,160,000
Triassic	13,000	16,250	16·25	11,375,000
Permian	12,000	15,000	15	10,500,000
Carboniferous	24,000	30,000	30	21,000,000
Devonian	22,000	33,000	33	23,100,000
Silurian	15,000	22,500	22·5	15,750,000
Ordovician	17,000	25,500	25·5	17,850,000
Cambrian	16,000	24,000	24	16,800,000
Keweenawan	50,000	75,000	75	52,500,000
Pinokee	14,000	21,000	21	14,700,000
Huronian	18,000	27,000	27	18,900,000
	265,000	357,850	357·85	251,095,000

In the above table notice has been taken only of actual strata in calculating the various ages, and no mention has been made of the great breaks in life-history which are noticeable in studying fossil remains, and these breaks may—indeed, in some cases must—represent great periods of time. Their actual duration could only be arrived at by discussion and agreement among geologists, but it is of course well recognized that the greatest breaks in the continuity of life occurred between the Permian and the Triassic systems and between the Cretaceous and the Eocene.[2] The very fact, however, that different names have been necessary in alluding to the systems suggests a possible break between each, and presuming that we must confine ourselves to about 250,000,000 years, as already shown, we must find room for the gaps during which no strata were deposited, by deducting some of the years allotted to each formation.[2]

[1] The principal *unconformities* have been considered and estimated for by the late Mr. J. G. Goodchild in his "Evidence regarding the Age of the Earth" (see Review in GEOL. MAG., 1897, pp. 115–117). Edinburgh, McFarlane & Erskine, 1897, and Proc. Roy. Phys. Soc. Edinburgh, vol. xiii, pp. 260–303.

[2] Mr. Goodchild liberally allows 70,200,000 years for *three* well-recognised *breaks* in his geological series, and for the whole period of geological time he suggests 701,235,000 years.

NOTICES OF MEMOIRS.

I.—The Geological Aspects of South African Scenery. Presidential Address delivered to the Geological Society of South Africa by Dr. Geo. S. Corstorphine, B.Sc., F.G.S.[1]

No country affords readier facility for the observation of the geological causes of scenery, though we may regret the fact that the facility owes its existence largely to the deplorable destruction of a former vegetation.

South African scenery is striking in its very monotony. Over hundreds, or rather thousands, of square miles there is a sameness which becomes oppressive, and a want of variety of feature which exceeds all imagining. There is nothing stimulating in the landscape but its immensity, yet, owing to the limited horizon, that immensity is not a characteristic immediately appreciated. The fascination of the veld is subtle and elusive, probably because, more there than anywhere else, is the charm due to conditions of sunshine and atmosphere, factors as essential to the final effect of a landscape as the configuration of the earth's surface.

The geological constitution and structure are the fundamental conditions on which the scenery of a country depends, and the resulting landscape is the outcome of the work done by the agents of denudation, which are themselves mainly due to the prevailing climatic conditions. Denudation working on the original structure, finding out the weak spots and gradually carving away even the hardest rocks, is the great factor in the evolution of a landscape. Whether that denudation is of one type or another, whether its weapons are rain, running water, snow and ice, or whether extremes of temperature aided by torrential tropical rains are the main modifying influences, depends on the climatic conditions. Similar geological conditions in regions enjoying different climates are subjected to different denuding forces, with the result that varied types of scenery are produced.

In a region such as South Africa, where the same geological formations extend from the Atlantic to the Indian Ocean, and from Agulhas to the retreating boundary of 'Darkest Africa,' the resemblances in the scenery are produced by the prevailing geological uniformity, and the differences are due to the variations in the climate.

It is to the action of long-continued subaerial denudation that South African scenery owes most of its characteristic features. Geological investigation reveals the fact that long ages have elapsed since the main stratigraphical structures originated, and that even the present land surface has an antiquity for which any possible equivalent in years would convey no meaning to the human understanding, for since the upper beds of the Karroo System were deposited only a small portion of the coastal region has undergone submergence.

[1] Annual General Meeting, 28th January, 1907 (Proceedings of the Geological Society of South Africa, 1907, pp. xix–xxvii).

The present surface, here as elsewhere, is the last expression of the interaction of various geological forces, some of which are as active to-day as they probably ever were, while others have in these days no share in the sculpturing of this landscape. Changes of temperature, wind and rain, surface and underground water, are probably not much less active in South Africa to-day than in past ages; whereas extreme glacial conditions have played no part in modifying the surface since the beginning of the Karroo Age, nor have volcanic agencies been at work since the eruption of the rocks of the Drakensbergen and the Lebombo Range.

The record of the South African strata tells us that before the present conditions began there were five periods during which a land surface existed. The earliest of these, and yet not the first, was formed by the complex mass of old rocks, now largely metamorphic in character, which we group together as the Swaziland System. To-day again these rocks play a large part in the constitution of the region, but whether any portion has remained continuously a land area cannot be determined. Certainly the northern granite and schist regions were dry land while the central and southern areas were gradually covered by the sea in which the Witwatersrand beds were laid down. These beds in turn were added to the land surface, and in the process of upheaval they underwent considerable folding and contortion. Having been again submerged, portions of the granite area, and probably the whole Witwatersrand System, formed the floor for the heterogeneous Ventersdorp System, with its succession of sediments and volcanic rocks, which in turn formed the third land surface that plays a part in the present one. When the next submergence ensued, the Black Reef, the Dolomite, and the Pretoria Series were deposited in the northern areas, which we know as the Transvaal, Bechuanaland, and Northern Cape Colony, though whether land conditions prevailed southward, or whether these beds were also deposited there, but were subsequently denuded, is again a matter of conjecture. At any rate, the evidence now available points to little deposition having occurred in the south during that period.

In the land surface next formed, the Swaziland, the Witwatersrand, the Ventersdorp, and the Potchefstroom or Transvaal Systems all played some part, there being a gradual increase in complexity from the north southward.

During the next submergence there was deposited the Cape System, consisting of the Table Mountain, the Bokkeveld, and the Witteberg Series, so predominant throughout Western and Southern Cape Colony, but represented in Natal by the Table Mountain Series only, and in the Transvaal most probably by the Waterberg sandstones and conglomerates.

When this period of deposition ended, the present terrestrial conditions began to prevail, for the characteristic Karroo System was not due to marine action, but, as is universally recognised, was formed mainly on the floor of an inland lake, while in the north land ice caused the extensive morainic deposit of the Ecca Glacial Conglomerate. This inland lake must have covered the greater portion of the region, and its shores certainly extended considerably south of the

Karroo, for we find its deposits in the Breede River Valley, south of the Langebergen. It seems likely that the lacustrine conditions prevailed longest in the east, north-east, and north, for it is only there that the Stormberg Beds, the youngest division of the Karroo System, are found, and we have no reason to believe that their absence in the south and west is due to denudation.

The disappearance of the Karroo Lake was probably accompanied by, if not actually due to, the upheaval of the only true mountain chains which characterise South African scenery, and it was doubtless during the same period of disturbance that the enormous volcanic activity now represented by the lavas of the Drakensbergen had its origin. The fossil evidence shows that this final upheaval most probably occurred in Jurassic times.

The submergences which occurred later affected only the coastal belt of the country, and are represented by the relatively small patches of Cretaceous rocks occurring in Cape Colony, Natal, and Zululand, and the strip of Tertiary beds on the coast of the last-named province. Throughout the greater extent of Secondary and Tertiary times the larger part of South Africa has been a land surface, and it is no wonder that its landscape should, to such an extent, show features due to denudation.

The present scenery has originated from the accretion of remnants of successive formations, each to a large extent formed by the disintegration of such portions of its predecessors as could be affected by the complex agents of denudation, while the sum-total as presented by the land of to-day is undergoing continuous modification by the denuding agents now at work.

For the present purpose South Africa may be regarded as falling into three zones—the Coastal Zone, the Mountain Belt, and the Interior Plateau.

The Mountain Belt.—The Mountain Belt is well developed in the west and south, and, as it is the essential feature in the structure of South Africa, I shall deal with it first. It embraces all the mountains which trend north and south on the western border of the Karroo and the various ranges which run east from Hex River Pass to the vicinity of Algoa Bay. This extended area consists of a series of true mountain chains, showing as much intricacy of structure as the Alps of Central Europe. The most conspicuous geological component is the Table Mountain Series, but the two higher members of the Cape System also play a part, while on the internal boundary of this zone the lower beds of the Karroo System are included in the mountain folds. Sections showing true mountain structure are to be seen in such places as Mitchell's Pass, Hex River Pass, and in the various passes and river gorges which cut the mountain chains from north to south, such as the Montagu and Prince Alfred's Pass over the Langebergen and the Gamka River Poort and the Zwartberg Pass through the Zwartebergen. Mountain scenery of the wildest and grandest type is to be seen among the Zwartebergen, the Langebergen, and the intervening ranges. Denudation has played a large part in the production of the present scenery, for the summits of all these ranges consist of Table Mountain quartzites, the geologically higher

Bokkeveld Beds being confined to the flanks of the mountain chains, or even to the valleys, while the more quartzitic Witteberg Beds may form subsidiary ridges. On the south-western coast of Cape Colony, and at intervals eastward to Algoa Bay, the mountain belt virtually reaches the coast: the Cape Peninsula itself is an outlying remnant, having been cut off by denudation from the hills on the western shores of False Bay.

The South Africa of to-day has lost a considerable portion of the mountain belt beneath the waves of the Indian Ocean, for from Algoa Bay northward through Natal we have no longer the same marked mountain scenery. Where the Table Mountain Beds appear in Natal they are lying for the most part horizontally, and though they form what are locally termed mountains, these, like the Cape Peninsula, are on the outskirts of the region of extreme pressure, which in eastern South Africa probably lies beneath the ocean.

Between such portions of the mountain belt as still exist in Natal and the more typical Langebergen and Zwartebergen of Cape Colony the contrast is very marked. In Natal the valleys are not structural valleys, but have been produced by the cutting out of great masses of the strata. The mountain tops are plateaux, formed of horizontal beds, whose edges form the sides of the deep-cut valleys.

The mountain belt being composed essentially of quartzites, those portions of it in the more arid districts of Cape Colony yield a very stern, bare landscape. In the east of Cape Colony and in Natal, however, the moister climate renders vegetation abundant, and we find the rocks of the mountain belt covered by bush, and even forest.

The Coastal Zone.—The Coastal Zone varies considerably in character, and, as has been already stated, it is in places actually cut out by the encroachment of the mountain belt. On the west coast it is perhaps most typical, consisting there of the old slates and schists of the Namaqualand Series, with bosses of intrusive granite. It presents a low undulating landscape, broken by hills of granite, which in places, as at Paarl and Robertson, are conspicuous features.

Along the west and south coasts, bare sand dunes are abundant, and some of the older of these have solidified into coherent masses, which are again being cut into by the sea. On the north shore of False Bay, and near Struys Bay, Cape Colony, there are cliffs 20 to 25 feet high, formed of these old sand dunes.

Where the mountain zone has encroached on the coast, as on the shore of False Bay, and many places eastward, the Table Mountain quartzites form steep sea-cliffs.

The eastern coast of Cape Colony and of a considerable portion of Natal is formed by the rocks of the Karroo, which, however, are much covered by recent coastal deposits. The lagoon landscape is particularly well developed along the Natal coast, owing to the heavy banking up of sand bars at the river mouths, while the Zululand coast is for the most part a low-lying belt.

The variation in the scenery produced by differences of climate acting on the same geological formations is again well illustrated in the coastal zone. The granitic and schistose rocks of the north-west, being exposed almost to desert conditions, show a bare and uninteresting

scenery—low undulating hills with a marked absence of river valleys. From the district of George eastward, and northward into Natal, the more generous rainfall renders forest vegetation possible; the granite tors and barren schist areas of the west are unknown, and numerous rivers flow seaward in deep-cut valleys. On the Natal coast the vegetation is still more abundant, and much of that area has an almost tropical character, though the geological formations are identical with those of the barren west coast.

The Interior Plateau.—The third area—the Interior Plateau—is the most extensive and also most varied in South Africa, showing the greatest diversity both of scenery and of geological constitution.

In the Cape Colony it consists of the Karroo, with its desert conditions, which disappear as one passes north-eastward into the Orange River Colony and the Southern Transvaal, though the same geological horizons prevail throughout these areas. Northward, the High Veld of the Transvaal consists, in addition to the Karroo Beds, of an extensive area where the older rocks, down to the oldest formation of all, have been laid bare. To discuss briefly the scenery of this vast interior plateau, it will be advantageous to deal first with the Karroo proper, and then the other areas built up of the rocks of the Karroo System.

The great Karroo is one of the most characteristic features of South Africa, and though its scenery may not be inviting, we may remember that it was the Karroo fossils sent home by Andrew Geddes Bain which first excited keen geological interest in South Africa, an interest which was stimulated on other sides by the controversy over the marvellous basal glacial conglomerate, while it was with the discovery of the Karroo diamonds that South Africa's importance to the modern world began.

The Karroo is built up of sandstones and shales which, except in the extreme south and west, where the lowest members of the series have been involved in the folding of the mountain belt, lie horizontally. Basic igneous intrusions, belonging to a late period in the geological history of the region, are everywhere abundant throughout the Karroo rocks. The Karroo scenery is a true denudation landscape. The hills which abound are remnants carved out from a surface once much higher. The flat-topped hills are in the earlier stages, the pointed ones in the later stages, of disintegration. The interbedding of harder sandstones with soft shales gives the alternate cliffs and slopes on the hillsides, while sheets of dolerite make the more marked escarpments, or krantzes.

Along the south of the Karroo, and well seen between Touws River and Matjesfontein, the slab-like weathering of the Glacial Conglomerate gives the hillsides a peculiar appearance.

The change of scenery which occurs from about the centre of the Orange River Colony northward into the central Transvaal coincides with the predominance of softer, more felspathic, sandstones, and the practically unbroken aspect of this portion of the High Veld is due to the more regular and homogeneous weathering which there occurs. There is not the same alternation of hard and soft rocks as in the Karroo proper, and the less arid climate enables the veld grass to protect the soil.

The whole of the central plateau, where the Karroo sandstones and shales form the surface, shows numerous ridges, scarcely to be called hills, which mark the site of basic igneous intrusions, which can often be traced for miles across the country. The west and south-west of the Orange River Colony often presents what may, on a small scale, be termed quite a rugged landscape, owing to the abundant presence of dykes and small irregular bosses of dolerite and allied rocks, which, even when forming no great elevation above the general level, stand out conspicuously from the grassy veld by reason of their dark colour and their growth of sparse bush.

The central Transvaal has been largely stripped of its covering of Karroo rocks, and the old rocks appear as mountain ridges, which are in every case a reappearance of a part of one of the older land surfaces. In this portion of the country, whether the rocks belong to the Witwatersrand System or the Potchefstroom System, the resulting scenery is practically identical—low, but abrupt, escarpments of quartzites, with dip slopes inclining north or south, and forming one side of a valley which has been carved out of the softer slates or shales. The Gatsrand, the Witwatersrand, the Witwatersberg, and the Magaliesberg are all instances of this type of scenery—east and west ridges with their escarpments facing north or south according as the beds dip south or north respectively. Each intervening valley has on one side a gentle declivity and on the other a steep precipitous wall.

In contrast to the long lines of sedimentary escarpments, which make many of the hills in the southern Transvaal, are the irregular masses of Ventersdorp amygdaloid, forming the Klipriversberg and the hills south-east of Heidelberg, while north of the Witwatersrand there is the undulating landscape due to the presence at the surface of a large extent of the old granite.

Beyond the Magaliesberg, where the great Bushveld massif of igneous rocks appears at the surface, the landscape opens out again into the broadly undulating type. The more basic of the rocks often form hills, such as the Pyramids or Zwarfkopjes north of Pretoria, but the granitic rocks give a scenery differing in no wise from that of the old granite, or, in fact, of any non-mountainous granite area. These rocks form a large part of the Bushveld proper, which in many places, with its grassy surface and irregularly dotted trees, has a close resemblance to the scenery of an English park.

Where the Waterberg formation appears resting unconformably on the Bushveld igneous rocks, or on the old granite of the north, there is a return to the escarpment and dip valley type of landscape, which is well seen in the hills north of the Premier Mine, the Waterberg itself, and the Zoutpansberg still further north. In all these hills the reddish-brown colour of most of the Waterberg conglomerates and quartzites is always a conspicuous feature.

By far the larger portion of the northern Transvaal is a granite landscape, presenting over thousands of square miles a gently undulating surface, with occasional bare tors rising like inverted bowls above the surrounding country. It is, except in rare seasons, a dry country covered by straggling thorn trees, above which rise the grotesque limbs of the fantastic baobab.

The same type of country extends northward into Rhodesia, and westward into Bechuanaland. In the former territory schist and slate ridges often form conspicuous escarpment hills, as along the Mazoe Valley, but it is the exception to find the granite rising into elevations which might rightly be styled hills. In the Transvaal, however, east of Louis Trichardt in the Letaba Basin, there are some conspicuous granite peaks, while the Matopos and the hills of the Lomagundi district, in Rhodesia, are other instances. All these, however, differ from such mountains as the Central Alps, in being due to the denudation of the surrounding country, and they can in no sense be regarded as true mountains of elevation.

The whole of the central plateau is a poorly watered country. The Karroo, in Cape Colony, has not a single perennial stream, and the rivers of the Orange River Colony are little better. Even the Vaal and Orange Rivers are, for the greater part of each year, only a series of standing pools over a large part of their upper, and often over their lower, courses. The best-watered regions are where the dolomitic limestone of the Potchefstroom System prevails, either in the southern or in the eastern Transvaal.

Few of the other rivers present much of the nature of river scenery as known in European countries. Those of the Karroo have broad shallow courses, covered with the boulders brought down in the rare times of flood. In the Orange River Colony many of the rivers have cut deep channels through the soil and soft surface deposits, but rocky gorges are not common, though good instances may be seen on the Caledon River on the Basutoland border.

The edge of the central plateau in eastern South Africa makes a marked physical feature, especially where it forms the great escarpment of the Drakensberg. But everywhere there is a more or less sudden drop from the High Veld down to the low country of the eastern coastal belt, whether over the basal granite, as in the Letaba Valley and at Waterval Boven, on the Delagoa Railway, or over the uppermost beds of the Karroo System, as in Natal and the Transkei.

The passage of the rivers from the central plateau to the coast zone presents considerable variation. In Cape Colony they have cut deep gorges through the Zwartebergen, Langebergen, and intervening ranges, but in Natal and the eastern Transvaal lofty waterfalls over the edge of the plateau are the common feature.

South Africa is absolutely devoid of lakes—such bodies of water as are often designated lakes being lagoons along the coastal belt, as in the George and Knysna districts, Cape Colony, and in the case of Lake St. Lucia, Zululand; or, like Lake Chrissie, in the eastern Transvaal, they are shallow depressions filled by rain-water in the wet years—in fact, simply enlarged pans.

Many interesting observations are readily possible as to the modifications now taking place of the scenery whose geological basis I have thus briefly sketched. Over a large tract of country rock-masses break up by alternate expansion and contraction due to the wide daily variation of temperature from noon to midnight throughout a large part of the year, and whether we look at the crumbling shales

of the Karroo kopjes or the massive granites of the Matopos, the same destruction is visible.

Even more obvious is the result of the torrential rains over the central plateau: we see channels cut or deepened before our eyes, and the soil of the country is carried seaward in vast quantities during every rainy season. The general surface, especially when the rain has been aided by wind, shows sometimes coverings of sand, sometimes fine gravel, decomposed from the surrounding rocks, and there are many places where this material has been accumulated to such an extent that it is often assumed to be due to an ancient river.

The intensity of these processes to-day is largely due to the scantiness of the vegetation, which is not always natural, but has been caused by the ruinous custom almost universally observed, of burning off the grass at the end of each Summer season. Instead of such senseless destruction of Nature's own protective covering, we might hope that it would now be realised that we need to add to, and not diminish, the vegetation of this part of the earth's surface. As geologists, we should willingly sacrifice our interest in observing the rapid action of denudation, when the first of each season's rains beat down on, and wash away, the soil laid bare through the destruction of grass or bush, for the knowledge that the land was not being wantonly impoverished year by year. We should even be glad to see many of these surface features, which are now so easily referable to their underlying geological features, hidden from us by a kindly growth of vegetation, and we should welcome a wise system of afforestation throughout the entire land.

In conclusion, gentlemen, I think you will agree with me that the natural and the political South Africa present some striking contrasts; geologically this part of the world has reached a maturity which no human system can hope to attain, politically the entire country is in an embryonic stage; geologically the region is the one throughout, but politically we have dismembered it. It appears almost as if Nature's plan had been too vast; her scheme too grand for poor humanity. Certainly, if the character of the people who have their home in South Africa develops in accord with the natural environment, pettiness of view or paltriness of aim will not be national traits—a country whose foundations are so wide cannot be the home of other than a broad-minded, large-hearted race, bound to play no mean part in the history of the world.

II.—General Report of the Geological Survey of India for the Year 1906. By T. H. Holland, F.R.S., Director. (Reprint from Records, Geol. Surv. India, vol. xxxv, part 1, April, 1907.

In the Introduction to his Report Mr. Holland states that "The great development of interest in Indian mineral deposits, as shown by the remarkable increase in the applications for concessions reported by the Local Governments, has had an effect also on the office work of this Department, and the duty of answering enquiries, instead of being a mere addition to the work of the officers at head-quarters, as was formerly the case, now consumes the largest fraction of our time."

It is satisfactory to learn that the Rt. Hon. the Secretary of State has sanctioned an increase in the graded list of gazetted officers, and the creation of a special post of chemist. The temporary posts for Mining Specialists have been abolished, in order to permit the appointments of permanent officers with a knowledge of mining. In order to assist in the development of the mineral resources of India, Mr. Holland visited during the year certain metallurgical and chemical works in England and Ireland.

Attention is drawn to the occurrence in India of highly aluminous laterites or bauxites that may prove to be valuable as a source of aluminium. Various other ore-deposits and economic products are referred to.

Investigations have been commenced with the view of supplying data on the problem of denudation, by determining the amounts of silt and dissolved salts carried into the sea by the larger rivers of India, and observations with this object were made on the Indus river.

Mr. E. Vredenburg, who was last year appointed Palæontologist to the Indian Geological Survey, has devoted attention to the fossils of the Lower Tertiary formations; Mr. F. R. Cowper Reed has completed an examination of the Devonian fossils collected in the Northern Shan States; and Professor Carl Diener has dealt with the collections of Muschelkalk fossils.

In Petrology assistance has been given by a former member of the staff, Dr. T. L. Walker, now Professor of Mineralogy and Petrology in the Toronto University.

Field-work was carried on in the Andaman and Nicobar Islands, in Baluchistan, Burma, Central India, and Kashmir, and the results of many interesting and important observations are summarized.

REVIEWS.

1.—The Scenery and Geology of Devonshire.

The History of Devonshire Scenery: An Essay in Geographical Evolution. By Arthur W. Clayden, M.A., Principal of the Royal Albert Memorial College, Exeter. 8vo; pp. viii, 207, with 43 illustrations. (Exeter, J. G. Commin; and London, Chatto & Windus, 1906. Price, 10*s.* 6*d.* nett.)

The Geology of Devonshire. By W. A. E. Ussher, F.G.S. Victoria History of the Counties of England. Devonshire, vol. i, pp. 48. (London: Archibald Constable & Co., 1906.)

The Hills and Valleys of Torquay: A study in Valley-Development and an Explanation of Local Scenery. By A. J. Jukes-Browne, B.A., F.G.S. 8vo; pp. viii, 104, with 7 plates (pictorial views), and 12 maps and diagrams. (Torquay: published by the Author, Floriston, Torquay, 1907. Price 3*s.* 6*d.*)

To those who have been accustomed to wield the hammer, there can be little doubt of the popularity and attraction of that branch of geology which deals with the sculpture of the earth's surface. The

enjoyment of scenery must ever be enhanced by a knowledge of the leading facts in the physical geography of former geological periods, and of the earth-movements and erosions that have combined to bring about the present contours of the land. The difficulty is to make the subject attractive and intelligible to those who have given no attention whatever to geology.

The history of Devonshire scenery is probably as complex as that of any other region of similar extent, and Principal Clayden, in putting before his readers the results of long study on the subject, has taken the opportunity of dealing somewhat generally with the physical geography of England in past times. He goes back, in fact, to the very beginning ere he comes to treat of "the date when the history of Devon begins to be readable from its own records." This commences in the Devonian period, inasmuch as "The identification of the Morte slates as Silurian appears to rest on insufficient data." From Devonian we are taken on to Carboniferous times, and then to "the Great Upheaval," when the main features of disturbance in the palæozoic rocks were produced. A consideration of the Dartmoor granite and Exeter lavas gives occasion for a chapter on igneous rocks; and the description of the New Red sediments for a discussion of scree materials, alluvial fans, and desert conditions. The author takes us as far as the Church cliffs at Lyme Regis when he treats of the Lias; and in dealing with later formations up to the Chalk and its palæontological zones, he makes excursions to Purbeck and the Isle of Wight. The formation of "the Post-Cretaceous peneplain" is held to be different from that described as "the Jurassic peneplain," beneath the Cretaceous rocks. In the words of the author, "The first was made by the advance of the sea modifying a land surface, the second by the retreat of the sea and the advance of land conditions over a sea bottom." Here we have still to deal with many difficult questions, concerning the age and origin of the earliest Tertiary strata in the district, and the earth-movements to which they were afterwards subjected. Comparing the Haldon gravels with those of the Bovey Basin, the author comments on the absence of Cretaceous strata beneath the beds at Bovey; while he argues that the Eocene beds of Haldon, which now rest on Upper Greensand, may have been accumulated on 200 feet of Chalk that has since been removed by solution. He suggests, indeed, that these Haldon beds may be older than the clays and lignites of Bovey, and coeval with London Clay or earlier Eocene. It is evident that we have still much to learn of the actual distribution of Eocene deposits on the Blackdown plateau, as at present they have not been clearly distinguished from purely local accumulations due to dissolution of the Chalk (clay-with-flints) and disintegration of Upper Greensand. Hence we feel inclined to await the results of further research before accepting the suggestion that "The Otter may thus be regarded as a former tributary of the Tone or of a magnified Parret flowing towards the north-east, while the Axe may have flowed direct into the head waters of the Dorset Frome."

The last ten pages of this volume are devoted to Modern Scenery, including uncovered Permian scenery, types of river erosion, and weathering of granite.

The author has given us a good outline of Devonshire geology, with sufficient information concerning the life-history of the successive periods to indicate the character of the physical conditions. He has, moreover, dealt with the successive epochs of erosion, deposition, and overlap, of depression and upheaval, which have resulted in the present form of the ground. If the plates giving restorations of ancient geography are 'ideal,' those picturing modern scenery and rock-structures are in nearly all cases excellent; and we can commend the book as one calculated to stir up interest and stimulate enquiry.

Mr. Ussher's account of the Geology of Devonshire is a lucid exposition of the general structure and palæontology of the county, to our knowledge of which he himself has so largely contributed. His work is accompanied by two admirable colour-printed maps, on which he has depicted the subdivisions he has personally made in the Carboniferous (three) and in the Devonian (eight). In dealing with the scenery he remarks: "There is no proof of the nature of the denudation of the palæozoic surface subsequent to the deposition of the Lower New Red beds, until the Cretaceous period. . . . . In this [transgression] and the subsequent deposition of the Eocene clays and gravels the older rock area was no doubt invaded, and the irregularities of its earlier contour planed and modified." The Bovey Basin, in his opinion, does "not appear to be due to local subsidences on fault lines, although the high dips of the sands on the south of the Bovey valley suggest such an explanation." He mentions that relics of deposits similar to Bovey Beds were noted by Mr. R. N. Worth on Plymouth Hoe, about 100 feet above O.D.; but he remarks that "The planed surfaces of the Devonian limestone hills of the Torquay, Brixham, and Plymouth area probably date from Permian times, as outliers of Lower New Red on the surface and in fissures are found near Waddeton and Brixham, etc."

Mr. Jukes-Browne's little book is one that deals with a limited tract of Devonshire, on which he has lived and laboured for some years. The object is to explain "the origin and gradual development of the physical features which contribute so largely to the popularity and attractiveness of Torquay." He has reproduced a portion of the Ordnance Survey map of 1809, with its graphic hill-shading, and he gives an interesting account of the original physical features of the neighbourhood of Torquay before it was much artificially modified. This description is further illustrated by the reproduction of a view from Castle Hill, sketched in 1824.

The author briefly points out the aims of geological investigation, and the agents to which the main forms of scenery are due, remarking "that a very little knowledge of geology will go a long way in explaining the origin of hills and valleys all over the world, as well as around Torquay in particular." This in view of what has been said before must be taken *cum grano*.

He gives an account of the many rock-types in the Devonian series; describes the Permian clay, conglomerate, and breccia in the district, and points out the disturbances and erosion that took place in the long interval between Permian and Eocene. To explain the development of scenery he has naturally to go beyond his immediate

neighbourhood, inasmuch as "It is absolutely necessary to realize that when the existing valley-system was initiated no Devonian rocks were exposed in the Torquay district, but that these rocks were partly covered and concealed by the Permian conglomerate, and completely buried beneath the Eocene deposits to a depth of several hundred feet. Consequently the surface on which the modern lines of drainage were first marked out was a surface of Eocene clay or sand, having a gentle slope from north to south."

He speaks of great lateral pressures as taking place during the Miocene period, whereby the Eocene beds between Bovey and Newton Abbot were bent into a deep trough: a remark which may be compared with that of Mr. Ussher previously recorded.

Dealing with the process of valley-making, Mr. Jukes-Browne points out "how the water-ways, which were established on one surface, have been gradually transferred to a lower and very different surface." Much of this erosion took place during Oligocene, Miocene, and Pliocene periods, when the land-surface was, in his opinion, perhaps 1,000 or 1,100 feet above sea-level, and the present land was about 400 feet higher than it is now. Erosion may "have been retarded for a time in the Pliocene period by the subsidence which allowed of the formation of the St. Erth Beds in Cornwall. It must, however, have been renewed by the subsequent elevation of the land, and was only brought to a close by the subsidence which ushered in the epoch in which we now live."

The author deals in some detail with the development of the local hills and valleys, and explains how the denudation has revealed and dissected the old plains, the effects of Eocene, if not of the great Cretaceous erosion. His conclusions thus differ considerably from those of Mr. Alexander Somervail, who, in an essay read before the Devonshire Association in 1886, referred the sculpture of the main valleys in and around Torquay to the era "between the close of the Cretaceous period and the dawn of the Tertiary."

II.—Festschrift Harry Rosenbusch gewidmet von seinen Schülern zum siebzigsten Geburtstag, 24 Juni, 1906. With a portrait, a geological map, 11 plates, and 35 figures in the text. $10'' \times 7\frac{1}{2}''$; pp. viii + 412. Stuttgart: Schweizerbart. 1906. M. 20 (unbound).

THIS volume, prepared by some of his students in commemoration of his 70th birthday, is dedicated to one of the most distinguished petrologists of the day. It contains 17 papers, all in German except those marked in the following notice by an asterisk, which are in English.

The first paper is by Prof. U. Grubenmann, of Zürich, "On some Swiss Glaucophane Rocks." He describes four glaucophane rocks of the Val de Bagne, Valais, and concludes that they are re-crystallized eruptive rocks of theralitic nature or their tuffs which were mixed with either calcareous or siliceous and aluminous material. Two erratic blocks from the canton of Bern have a similar character.

Prof. W. H. Hobbs (Michigan University), "On two new occurrences of the 'Cortlandt Series' of Rocks within the State of Connecticut."* The localities are Prospect Hill, near Litchfield, and Danbury to New

Fairfield. Prof. Hobbs concludes "that the generally rare gabbro, norite; peridotite, and pyroxenite types which most nearly correspond to the original 'Cortlandt Series' belong to a single magma which has here been intruded along the mutual borders of areas of granite, grano-diorite, and diorite, which may themselves have mingled to some extent; and that it has itself been later intruded by a fine-grained diorite. The extreme magmatic differentiation of this gabbroitic magma has been locally increased through the fusion with it of granite and grano-diorite."

Prof. E. A. Wülfing (of Kiel). "A Note on the Pigments of Minerals," describes experiments on the subject of the pigments in coloured minerals, leading to the important conclusion that pigments exercise no appreciable influence on the refraction of the minerals in which they occur.

Dr. C. Hlawatsch (of Vienna). "On the Amphibole of Cevadaes (Portugal)," describes an amphibole in the so-called arfvedsonite-gneiss of Cevadaes near Campo Mayor. It is intermediate in character to riebeckite and arfvedsonite, and Hlawatsch proposes to call it Osannite after Prof. A. Osann of Freiburg-i.-B.

Dr. E. O. Hovey (of New York). "The Geology of the Guaynopita District, Chihuahua: A contribution to the knowledge of the structure of the Western Sierra Madre of Mexico."* The oldest rock described is a semi-crystalline, much metamorphosed Cretaceous limestone, completely overturned and flexed in Guaynopita mountain. This folding was followed by the eruption of andesitic breccias, ash and flows, which are probably somewhat unconformable to the limestone; granite was then intruded, resulting in the completion of the elevation and metamorphism of the limestone; dacite, rhyolites, and basalt were afterwards extruded.

Prof. O. Mügge (of Königsberg). "The Rate of Decomposition of Quartz in the presence of Hydrofluoric Acid: A contribution to the Theory of Etched Figures."

Prof. L. Milch (of Breslau). "On Differentiation in Granitic Magmas from Observations on the Granite of the Riesengebirge."

Prof. M. Koch (of Berlin). "Note on the Olivine-diabases of the Upper Harz."

Dr. R. A. Daly (of Ottawa). "The Differentiation of a Secondary Magma through Gravitative Adjustment."* The paper describes the Moyie sill of hornblende-gabbro intrusive in quartzite in the Purcell Mountains, on the boundary between British Columbia and the United States. At the upper junction of the sill with the quartzite an abnormal biotite-granite is developed, which Daly attributes to digestion of quartzite in the hornblende-gabbro, at both the upper and lower contacts of the sill. He supposes the material digested at the lower contact to have mostly risen by gravitation through the whole thickness (840 metres) of the sill and accumulated at the upper contact.

Dr. E. Becker (of Heidelberg). "The Wartenberg near Geisingen in Baden." The columnar nepheline-melilite-basalt and associated eruptive breccia of the Wartenberg are allied to the other Swabian embryonic volcanoes (of Branco), and are to be regarded as filling a volcanic neck. The neighbouring Fürstenberg is believed to contain a similar volcanic nucleus.

Prof. A. Osann (Freiburg-i.-B.), "On some Alkali-rocks from Spain," describes three rock-types. (1) A verite from Fortuna in the province of Murcia, previously described by Ramon Adán de Yarza as 'fortunite.' It is a glassy facies of (2) a rock termed by Yarza a trachyte, but which Osann proposes to call 'fortunite.' This fortunite (Osann) exhibits microscopically phenocrysts of almost colourless rhombic pyroxene, which is the only constituent to occur in two generations. It is accompanied in the groundmass by monoclinic pyroxene allied to diopside, phlogopite (mica), sanidine, apatite, ilmenite, and a not inconsiderable amount of glassy base. (3) The parent rock of the Jumilla apatites, which occur in veins traversing the volcanic rock. The rock is allied to the orendites of Whitman Cross, and Osann proposes to call it 'jumillite.' It is the first rock rich in leucite to be described as occurring in Spain.

C. Palache (Harvard University), "On Octahedrite, Brookite, and Titanite from Somerville, Massachusetts, U.S.A.,"* describes the occurrence of these titanium compounds in veins in diabase, from the alteration of the ilmenite in which he holds that they are derived. Twin structure with (101) as twin plane in octahedrite is recognized for the first time, and the alteration of brookite to sagenitic aggregates of rutile is recorded.

Dr. H. Preiswerk (Bâle), "Malchites and Vintlites in the Stroma- and Sesia-gneiss (Piedmont)," describes two dykes of hornblende-malchite and one of mica-malchite at Lago Mergozzo, near Lago Maggiore, a dyke of diorite-porphyrite in Valle Canobbina and a vintlite (diorite-porphyrite) from a pass east of Gaby in Val Gressoney.

Prof. G. Steinmann (Freiburg-i.-B.), "The Origin of the Copper-ore Deposits of Corocoro and allied occurrences in Bolivia." The deposits described are limited to the inter-Andean plateau of the Bolivian Cordillera and occur in the Cretaceous Puca sandstone. The copper occurs chiefly in the metallic state. Prof. Steinmann regards it as a subsequent deposit. He believes it was contained in a solution in which sulphuretted hydrogen, sulphurous acid, and perhaps also carbon dioxide were the gaseous constituents. In order to obtain from such a solution metallic copper oxidising substances are requisite, and such are everywhere present in the sandstone, as iron oxide or hydrates. The sulphides of the solution will be oxidised, the sandstone will be bleached (as it is around the copper), the metal will be set free, and gypsum (usually present in the deposits) will be formed. Prof. Steinmann believes the ultimate source of the copper to be in the Tertiary Andes granites, diorites, and hypocrystalline porphyritic igneous rocks.

Dr. Th. Nicolau (Jassy), "The Aragonite of Sarul Dornei," describes needle-shaped crystals found in cavities of a sandy marl in Moldavia.

Dr. L. Finckh (Berlin), "The Rhomb-porphyries of Kilimanjaro," describes the rocks of Kilimanjaro previously described under other names by Prof. Bonney,[1] J. S. Hyland,[2] and Tenne.[3] They agree in

[1] Min. Mag., No. 32 (1886), pp. 10–12.
[2] Tschermak's Min. & Pet. Mitt., vol. x (1888), p. 263.
[3] H. Meyer: "Ostafrikanische Gletscherfahrten," Leipzig, 1890, p. 305.

essentials (except in bearing leucite) with the kenyites of Mount Kenya,[1] and belong to the family of trachy-doleries. The phenocrysts consist of anorthoclase, olivine, nepheline, hauyne (scarce), magnetite, apatite, ilmenite, and zircon, and the groundmass, often more or less glassy, contains anorthoclase, olivine, nepheline, leucite, diopside, ægirine, ægirine-augite, lävenite (?), anomite, eossyrite (scarce), catophoritic hornblende. As secondary minerals, pseudobrookite, analcite, and other zeolites, calcite, and hyalite occur. According as nepheline or leucite predominates, the rocks may be divided into Nepheline-rhomb-porphyries and Leucite-rhomb-porphyries.

Dr. W. Wahl (Helsingfors, Finland), "On a Magnesium-diopside-bearing Diabase from Källsholm, Skärgärd (skerry well) of Föglö, Aland Islands," describes a diabase containing a magnesium-diopside chemically very similar to that in the diabase of Richmond, Cape Colony, and the mixture of pyroxenes in the Hunne diabase of Halleberg (at the south end of Lake Vener in Sweden). The rock chemically resembles the olivine-diabase of Rhosson, near St. Davids,[2] and the Whin Sill[3] of Cauldron Snout.

Dr. Wahl's paper is the last in the volume, but owing to a mistake of the post-office a paper by Mr. A. C. Lane (State Geologist, of Lansing, Michigan, arrived too late for inclusion. It is entitled "Die Korngrösse der Auvergnosen" (the size of grain of the auvergnoses), and deals with the practical and theoretical conclusions which may be drawn from the microscopical study of the size of the constituents of igneous rocks, especially the quartz-diabase of the Medford dyke near Harvard University. The paper is published by Schweizerbart, Stuttgart, in the same style as the Festschrift.

B. Hobson.

III.—European Animals: their Geological History and Geographical Distribution. By R. F. Scharff, Ph.D., B.Sc., Swiney Lecturer on Geology. 8vo: pp. xiv and 258, with 70 illustrations. (London: Archibald Constable & Co., Ltd., 1907. 7*s.* 6*d.* net.

THE most appropriate motto for the present volume would have been the author's own words quoted below, with the last sentence in italics, as we print it. "Our fossil evidence is of so very fragmentary a character that it is often extremely difficult to point to any particular country as the home of a species or genus. *The present distribution, however, may be looked upon as a reliable guide in directing our inquiries in this respect.*"

On the other hand, it would seem to us rather that "The present distribution must be looked upon frequently as a fallacious guide in directing our inquiries concerning the home of a species or genus."

Herein lies the one grievance we have with the contents of this otherwise excellent book. There is also in our opinion too much prominence given to migration, to marches and countermarches; and we must further disagree with the author where he assumes an extraordinary longevity of Mammalian species.

[1] G. T. Prior: Min. Mag., vol. xiii (1903), p. 247.
[2] Sir A. Geikie: Quart. Journ. Geol. Soc., 1888, p. 503.
[3] Teall: Quart. Journ. Geol. Soc., 1884, p. 654.

We just spoke of *one* grievance, and here we have already pointed out three to begin with. The fact is, there exists a connection between these different matters; they can therefore be all summed up under one head. The present distribution, of course, depends more or less on migration (it is the divergence of opinion about the more or less which makes all the difference); and when the author assumes the possibility of a species of Mammals dating from the Tertiary, Pliocene, or Miocene, his conclusion is influenced by considerations taken from its present distribution.

What is 'geological history' of European animals? Just as the history of a nation is the account of the origin and evolution of that nation, so the history of European animals is, or ought to be, the account of the origin and evolution of European animals. By adding 'geological' to 'history' emphasis is laid on their origin and their past history generally. We are therefore led to assume that the author realises that biogeography cannot dispense with the teachings of palæontology. As a matter of fact, however, he has just told us that he can do without it. Pleistocene forms of life are frequently mentioned throughout the book, but Tertiary forms to a much lesser extent; since, however, the author frequently refrains from drawing any inferences from them they are generally little more than ornamental additions.

That our present fauna and flora are rooted in the past had already been acknowledged by Edward Forbes, who was far in advance of his time. Compare, for instance, his work, published in 1846, with Grisebach's "Vegetation der Erde" of 1872. Forbes, however, was a pre-Darwinian, and of necessity made use of pre-Darwinian language. When he recognises a Miocene element in the flora and fauna of the British Islands, his interpretation of the phenomenon is that Miocene plants and animals have been preserved to the present day without changing their specific identity. Migrations have to explain their survival with us, and to help generally over all other difficulties.

Dr. Scharff has taken Forbes for his model, but he apparently has not always kept in mind that modern biogeography, like modern systematic zoology and botany, cannot discard phylogenetic views. If you are opposed to these, it is best to say so, and to give the reason why; but you cannot ignore them.

On comparing the title of Dr. Scharff's book of eight years ago[1] with the title of the present one we should naturally expect to find in the latter more about the *geological* history of European animals than in the former; on comparing the contents, however, we discover that the opposite is the case. We ask ourselves if all this is done intentionally, if our author by chance wishes us to revert to Edward Forbes, i.e. to bring our present biogeographical work in consonance with the views of him who "has laid the foundations of a new method of research."

It is quite true that fossil evidence is often fragmentary; still, in the two groups from which the author draws the majority of his examples, snails and mammals, much work has been done in this direction.

[1] "The History of the European Fauna," London, 1899.

In order to substantiate the grounds for our 'grievance,' we select and discuss a certain number of the author's illustrations which are to the point. Of the *beaver* it is stated (pp. 57–58) that, whilst now practically extinct in Western Europe, it is still plentiful in Russia and throughout Siberia. "We have here an example of an animal which evidently spread westward from the east, since it has never been found fossil in either Ireland, Italy, or Spain, where we should expect it to occur if it had originated in the west." About Ireland Dr. Scharff knows best. As regards Spain, it is dangerous to draw inferences from negative evidence in a country where so little is known of the Pleistocene fauna. With respect to Italy, no country of the world has yielded remains of beavers from so many different geological horizons as that country. They occur in the peat (Varese and elsewhere), in the interglacial lignites of Leece, in the older Pleistocene of Arezzo, and lastly at least one species is known from the Upper Pliocene of the Val d'Arno. The latter is different specifically from the recent species, and the form from Arezzo has also been assigned to a distinct species. All are so nearly related that they were probably evolved from each other.

Our conclusions with regard to the distribution, past and present, of the mole (*Talpa europæa*) mentioned on the same page (p. 58) are very similar to that of the beaver. It would require pages to enter fully into the particulars of the case. The conclusions of the author are based in these instances upon incomplete and erroneous premises. What he says about the present distribution of the European mole is equivalent to stating that it has migrated from a region where it does not exist, and never existed for all we know, to one where it has existed since Pleistocene times. It appears to have escaped the author's observation that the mole of the Caucasian regions is different from the European; the Altai mole is still more dissimilar. On the other hand, nearly related forms are known from Southern Europe. As in the case of the beaver, we know the mole from European Pleistocene deposits, remains of a distinct species are known from the Pleistocene of Sardinia, and remains of Tertiary species have been found in various parts of Europe. There is therefore sufficient evidence to justify the assumption that *Talpa europæa* has been evolved in Europe.

In the fauna of the Spanish Peninsula "we have evidence of the existence of a very ancient endemic element" (p. 105). There is a North African fauna, too, in South Spain which is more recent than the endemic Lusitanian fauna. "The Lusitanian area was invaded by a North African fauna" (ib.), which itself is of old date, for "the African forms came to Spain in Miocene times."

It has hitherto been assumed—and in our opinion rightly—that the Spanish Peninsula owes the archaic elements of its fauna and flora to long isolation, a condition which must have rendered this region particularly unsuited to the rôle assigned to it on p. 100 of having been "a centre for distribution of species."

As regards the African forms in the recent Mammalian fauna of Spain, our knowledge of them, both in Spain and North Africa, is still imperfect. But this much may be asserted, when the author

claims that these African forms came to Spain in Miocene times he commits a double heresy, namely, that they remained unaltered since the Miocene and remained so in two separate regions.

It ought to be clearly understood that no single living Mammalian species, Hyæna striata not excepted, existed so far back as the Pliocene.

Over and over again the well-established fact of the comparatively short duration of mammalian species is ignored by the author. For instance, on p. 224 we read: "The mammalian fauna of the North African Tertiary deposits has by no means been exhaustively examined, yet an extremely rich osteological collection has been brought together from Algeria. It has been shown that several kinds of hippopotamus, the rhinoceros, lion, buffalo, horse, wild ass, several antelopes, a camel, and many of the species which had been discovered at Pikermi, in Greece, had likewise lived in North-West Africa in the past, and had even persisted there up to Pleistocene times."

The mention of the Pikermi fauna, of which nothing is said when discussing the ancient land surface across the Ægean Sea, is quite out of place here; that the species found at Pikermi persisted to Pleistocene times is erroneous, and apt to lead to endless confusion. The Algerian deposits referred to are mostly Pleistocene or even alluvial; there is a doubt in some instances whether Upper Pliocene Mammals have been mistaken for Pleistocene, or *vice versâ*.

Arctomys.—We agree with the author that the Alpine fauna—as well as the Alpine flora—is of pre-Glacial origin, and that during the height of the Glacial period the Alps were not devoid of organic life. A species of marmot (*Arctomys*) has been found in Upper Pliocene deposits of Auvergne. From its extreme rarity it seems probable that the species did not live on the spot, but, like many of its extant relatives, was a dweller on mountains, and that its remains were only occasionally carried down by floods and entombed in lacustrine deposits.

Our author comments on the different species of the genus as follows:—"Like the chamois the Alpine marmot (*Arctomys marmotta*) is disseminated over several other European mountain ranges besides the Alps, and there is some fossil evidence of its having spread into the plains in Pleistocene times . . . . . The Russian marmot (*Arctomys bobac*) formerly invaded the North European plain, and has since retreated to the eastern parts of our continent, whence it came. The Russian marmot is found right across Siberia as far as the Amur, and there are no less than ten other kinds of marmots in Asia. Asia is consequently the centre of distribution from which the marmots have radiated west and east, for five species have penetrated into Arctic North America. That this took place in pre-Glacial times is evidenced by the fact that one species is known from American Pliocene deposits" (p. 139).

We have just mentioned that a species is known also from European Pliocene deposits: the genus may already have been with us long before the Upper Pliocene. The recent discovery in the Oligocene of North America of a genus nearly related to *Arctomys* suggests that the latter may have been evolved in that continent, and *thence* spread east and west. The genus having existed in Western Europe *before*

the Pleistocene, there is no stringent necessity for applying to Pleistocene migrations in order to explain its presence with us in that period. We have our doubts as to the soundness of the doctrine asserted by the author that a steppe fauna marched wholesale with flying colours into Central and Western Europe during post-Glacial times and marched back again. Several of the eastern steppe mammals—the bobak one of them—certainly extended formerly more to the west than they do at present; others of the supposed invaders prove one after the other, on closer examination, to be specifically distinct from eastern forms. The marmot found in a cave of Northern Germany (Gera) is closely related to the bobak, but still differs more from the latter than does e.g. the Turkestan marmot (*A. dichrous*, Büchn., *nec* Anders.). It is the same with the susliks. The most diffuse of our Pleistocene susliks is quite generally identified with the *Cit. fulvescens* of the Ural Mountains, but it is likewise a distinct species.

The hopelessness of the undertaking to map out the islands and continents of a former epoch or of former epochs by the *existing* distribution of animals, to the exclusion of palæontological evidence, cannot be better illustrated than by the following passage: "If the opinion, expressed by several authorities, as to the extreme antiquity of the fauna of these islands [Sardinia and Corsica] should be substantiated, we could establish thereby the age of the European fauna as a whole. We should be able to discover the precise age of some of the animals inhabiting the British Islands. For in Sardinia and Corsica there occur such species as the field-mouse (*Mus sylvaticus*), which has a very wide European range and extends as far north as Iceland" (p. 215). From the context we gather that by "extreme antiquity" the Miocene is meant, for the author had just quoted Kobelt's contention "that these islands [Sardinia and Corsica] became separated from the continent in Miocene times, and that they were never since connected with it." He also refers to another malacologist's (Simroth's) suggestion of an immigration (in Corsica) in Miocene times. The author therefore implies that *Mus sylvaticus* may be a Miocene species! *Mus sylvaticus* occurs in fact in both islands, together with other mammals, which, with the exception of the Mouflon, are not represented in the Pleistocene deposits. The Pleistocene Mammalia of these islands, which the author does not discuss, point towards a continental connection in the Tertiary and their isolation at the end of that period. To explain the presence of the recent mammals we are therefore offered the following alternative. We must either adopt Dr. Scharff's suggestion that the recent Mammalian species, in spite of their absence from Pleistocene deposits, and in spite of their absolute identity with continental species, including small details in the coloration of their skin, already inhabited these islands in Tertiary times and have preserved their specific identity ever since. Or else we must accept the conclusion which has recently been arrived at, viz., that with the exception of the mouflon all the extant Mammalia of Corsica and Sardinia have been introduced by man, either intentionally or unintentionally. We think there can only be one opinion.

We have limited our criticisms almost exclusively to the rôle assigned by the author to the existing fauna, because that is the

leading idea of the book. We have chosen the examples from the mammals for convenience sake, and because a great part of the work is devoted to this class by the author himself. We refrain from pointing out other matters in regard to which we disagree with the author; indeed, it is high time that we should speak of the excellent qualities of the book.

Everyone who has done work on similar subjects knows by experience how tedious it is to collect the necessary information whenever he has to travel outside his own department. In the present volume a prodigious amount of facts from many classes of the animal kingdom, with frequent references also to the flora, have been laboriously collected and discussed. In going over the bibliographical appendix we become aware that all the more recent publications on geographical distribution deal with but one or a few zoological subdivisions; so that Dr. Scharff's book is really an indispensable repertory of zoogeography, brought up to date. At the same time it loses nothing of its suggestiveness for advocating in some instances views whose accuracy is, in our opinion, open to discussion.

The numerous maps showing the distribution of single species or genera are exceedingly useful and instructive, many of them representing a vast amount of painstaking work. The hippopotamus (p. 78) shouting "Excelsior!" from the top of his mountain is both amusing and harmless.

On the whole it is a volume of great utility which we should be sorry to miss from our bookshelf. C. I. Forsyth Major.

IV.—The Geology of the South Wales Coalfield. Part IX: West Gower and the Country around Pembrey. By Dr. A. Strahan, F.R.S., with notes by B. S. N. Wilkinson, T. C. Cantrill, and E. E. L. Dixon. Memoirs of the Geological Survey. 1907. Price 8*d*.

THIS is an inexpensive explanation of an interesting tract in South Wales; the western half of the promontory of Gower with a part of the main coalfield between Llanelly and Pembrey. The advantage of a 'solid' as well as a 'drift' edition of the map is apparent. Placing the two sheets side by side, we can readily grasp the structural features of the country from the solid edition, but it would be a difficult matter to decipher this from the map which shows the greater portion of West Gower to be covered with Boulder-clay. For practical purposes both editions are equally necessary, and this fact is accentuated by the addition in the memoir of a valuable map of the unproved coalfield beneath the Loughor and Burry Estuary. The rocks described include the Silurian, Old Red Sandstone, Carboniferous, Trias, and Superficial deposits; and it is worthy of note that attention has been given to the zonal divisions in the Carboniferous Limestone Series. Among the Pleistocene phenomena, the Raised Beach, the Bone Caves, and the Glacial drift furnish interesting data which support the conclusion that the mammalia lived before the first manifestations of glacial action in South Wales.

V.—The Stone Implements of South Africa. By J. P. Johnson. 4to, cloth; pp. 53, with 258 illustrations. (London: Longmans, Green, & Co., 1907.)

IN this work the author embodies the results of his contributions, made during the last four years, to our knowledge of the Stone Age of South Africa. At the same time, while no attempt is made "to review the abundant, but unsatisfactory, literature already in existence," he makes mention of the work of many other observers.

He records the occurrence at Lejfontein of Eoliths belonging to two groups: (1) Those in which the pieces of stone have been subjected to very little modification; and (2) those in which they have been chipped into definite shapes. He reasonably observes that, if the Eoliths represent the earliest types of man's handiwork, "one would expect them to be barely distinguishable from Nature's work. Their association with others in which the trimming, though of the same rude kind, is arranged in definite patterns is the sole ground upon which they can be accepted." The illustrations include forms identical with many found in England.

Other implements from the Zambesi Valley in the vicinity of the Victoria Falls are described. Attention was first drawn to these by Colonel Feilden, and they have since been figured and described by Mr. G. W. Lamplugh (Journ. Anthrop. Inst., vol. xxxvi, 1906), who remarked that "many of the specimens show a secondary chipping which corresponds more nearly to rough European Neolithic work than to the earlier Palæolithic period." Mr. H. Balfour, who followed Mr. Lamplugh, described in the same journal a characteristic type of Palæolithic implement also from that region. Mr. Johnson regards many of his specimens as belonging to the transition between the Eolithic and Palæolithic stages of culture. He records typical Palæolithic implements from the deposits of the Vaal and Orange Rivers and elsewhere; and figures some minute flakes and scrapers, fashioned out of chert, jasper, and agate, from Taaibosch Spruit, a tributary of the Vaal, above Vereeniging, and from other localities. Newer or advanced types of implements are described from rock-shelters in the Asbestos Hills and elsewhere.

VI.—Maryland Geological Survey.

1.—The Pliocene and Pleistocene Deposits of Maryland. By George Burbank Shattuck. pp. 291, 75 plates, and 10 text-figures. Baltimore: The John Hopkins' Press, 1906.)

THIS is the third of a series of reports on the systematic geology and palæontology of Maryland. The first and second volumes were devoted to the Eocene and Miocene deposits.

The Pliocene and Pleistocene formations of Maryland (as remarked by the State Geologist) have exercised a potent influence upon the surface configuration and soils of Maryland; and they are spoken of by the author as "the last of a long series of unconsolidated beds which began to be deposited in Lower Cretaceous and possibly Jurassic time, and have continued on with interruptions down to the present. These deposits are composed of clay, peat, greensand, marl, gravel,

iron ores, and ice-borne boulders." The Pliocene deposits have yielded no fossils; on the other hand, those of Pleistocene age have yielded a diversified fauna and flora. The Mammalia are described by F. A. Lucas, the Reptilia by O. P. Hay, the Insecta by E. H. Sellards, the Crustacea, Mollusca, Coelenterata, and Protozoa by W. B. Clark (State Geologist), the Molluscoidea by E. O. Ulrich, and the Plants by Arthur Hollick.

The volume is copiously illustrated with maps and diagram-sections, with photographic plates of scenery and geological phenomena, and figures of the organic remains. One plate gives a restoration of the American Mastodon, *Mammut americanum* (Kurr).

2. — Report on the Physical Features of Maryland. By Wm. Bullock Clark and Edward B. Mathews. pp. xv, 284, 30 plates, 19 text-figures, and geological map of Maryland. (Baltimore, 1906.)

This is in reality a handbook to the country, embracing an account of the physiography, geology, mineral resources, agriculture, climate, hydrography, terrestrial magnetism, and forestry. It summarises the information acquired, and will help to make popular the results of the Geological Survey. Among the illustrations are plates of characteristic fossils from Silurian to Pleistocene. The well-printed geological map shows clearly the various formations, and to the description of these are appended notes on the characters of the soils, and the crops they yield.

VII.—Iowa Geological Survey.

WE have lately received the sixteenth volume of the publications of this Survey, including the Annual Report for 1905 and accompanying papers dated 1906. Under the direction of Dr. Frank A. Wilder, State Geologist, special attention has been given to economic geology; and he remarks: "There is a large and steadily increasing demand on the Survey made by residents of the State for assistance in investigating problems and examining specimens which seem to have economic significance. I have no doubt that in this the Survey at this stage in its development will render its greatest returns to the State, and the Director and his assistants have not hesitated to give freely of their time in answering appeals for examinations of mineral localities."

Reports on the geology of eight counties are included, together with statistics of the mineral production in Iowa for 1905. There was an increase in the production of coal, gypsum, and sand-lime brick.

VIII.—Alabama Geological Survey.

AN instructive report on "The Underground Water Resources of Alabama," by Mr. Eugene Allen Smith, has been published. As usual, there are introductory chapters on the physical geography, geology, and climate, and on the general principles of underground waters and artesian wells. These are followed by detailed descriptions of the wells, springs, and mineral waters of the country.

REPORTS AND PROCEEDINGS.

I.—Dorset Natural History and Antiquarian Field Club.

Under the guidance of Mr. W. H. Hudleston, F.R.S., an interesting and instructive excursion was made by sea to view the cliffs of the Isle of Purbeck and their continuation towards Weymouth. Leaving Swanage soon after midday on July 9th, the party embarked on board the steamer "Empress" and proceeded northwards towards the Foreland to examine the famous thrust-fault in the Chalk of Ballard Down. Returning thence to Swanage the downward sequence of strata was observed from the basal Chalk, through the Upper Greensand, Gault, and Lower Greensand of Puntield to the broad stretch of Wealden sands, coloured clays and lignites of Swanage Bay. Onwards by Swanage to Durlston Head the Purbeck Beds were well seen, based on the stronger Portland rocks which front the sea westwards to St. Ealdhelm's (St. Alban's) Head and Emmit Hill. Here, as the Director pointed out, we see the effects of an anticline which brings up the Kimeridge Clay, while the Portlandian escarpment commences to wind inland, and after producing the eminences of Hound-tout and Swyre Head, passes in a noble sweep through Smedmore Hill and Tyncham Cap into the final precipice of Gadcliff. Attention was drawn to the features of the Kimeridge Clay, its "coal," its ledges formed by cement-stone bands, and the numerous faults. Beyond Gadcliff the diversified features of the coast attracted much attention. Here the rampart of Jurassic rocks has been broken through, and the sea reaches the vertical Chalk in Worbarrow Bay; in Lulworth Cove, Man-of-War Cove, and other picturesque inlets, opportunity was taken to demonstrate the effects of denudation and of the remarkable disturbances to which the strata have been subjected. Westwards attention was drawn to the fine cliffs of Chalk and Upper Greensand of White Nothe, and the striking unconformity of Gault on the Purbeck, Portland Beds, and Kimeridge Clay below Holworth House. Thence to Weymouth lower strata were observed in the Corallian beds of Osmington and in the Oxford Clay which forms the low cliff north of the town. Thus ended a most enjoyable excursion in which the main features in the geology of Eastern Dorset, so grandly exhibited in the coast-sections, were viewed and explained under fairly favourable circumstances. About 120 members and their friends, including the President and all the executive, took part in it, and had the weather been less threatening the attendance would, no doubt, have been more numerous.

II.—Geological Society of London.

June 19th, 1907.—Aubrey Strahan, Sc.D., F.R.S., Vice-President, in the Chair.

The following communications were read:—

1. "The Inferior Oolite and Contiguous Deposits of the Bath-Doulting District." By Linsdall Richardson, F.G.S.

In this paper a detailed description is given of the Inferior Oolite of the country between Doulting and Bath. The beds have been studied at different localities within the area by several geologists, but in most cases only the actual facts observable were recorded—there was little or no attempt at correlation. Now it is shown that there is within the area no Inferior Oolite deposit of earlier date than the Upper *Trigonia* Grit—a deposit of *Garantiana* hemera. In the hills south of the Avon Valley at Bath, and as far southeas a line drawn east and west through Carnicote, near Timsbury, this deposit rests upon the Midford Sands. South of this line, and between it and one similarly orientated about half a mile farther south, it rests upon the local Cephalopod Bed: here of greater antiquity than the 'Sands' Midford); not younger, as in the case of the Cotteswold Cephalopod Bed. South of the latter line, the Upper *Trigonia* Grit, often conglomeratic, rests upon the non-arenaceous Liassic deposits, until in the more immediate neighbourhood of the Mendip Hills it is overstepped by the Doulting Stone, which rests directly upon the well-planed, bored, and oyster-strewn surface of the Rhætic White Lias and the Carboniferous Limestone. On the south side of the Mendip Hills the Upper *Trigonia* Grit comes in again.

The Fullers' Earth at Midford, at least the lower part, is of *zigzag* hemera. The intervening Inferior Oolite between it and the Upper *Trigonia* Grit may be thus divided, dated, and compared:—

Fullers' Earth			*(zigzag).*	
Inferior Oolite.	Doulting Beds.	I. Rubbly Beds.	(inter-*zigzag* *Truellii.*)	*Clypeus* Grit of the Mid and North Cotteswolds.
		II. *Anabacia* Limestones.		
		III. Doulting Stone.		
		IV. Upper Coral Bed (*Truellii*)		= 'Coralline Beds' of Dundry.
		V. Dundry Freestone		(Usually absent.)
		VI. Upper *Trigonia* Grit (*Garantiana*).		
(Non-Sequence) Lias.				

In one appendix Mr. S. S. Buckman indicates the deposits in Dorset equivalent to the above; in another the late Mr. J. F. Walker and Mr. Richardson deal with the Brachiopoda of the Fullers' Earth, naming seven new species; and in a third, Mr. Richardson describes a new *Amberleya* and *Spirorbis*. The micro-fauna of the Upper Coral Bed is dealt with by Mr. C. Upton, who obtained from material furnished him from Midford and Timsbury Sleight most of the micro-Brachiopoda such as were found by Charles Moore at Dundry Hill.

2. "The Inferior Oolite and Contiguous Deposits of the District between the Rissingtons and Burford." By Linsdall Richardson, F.G.S.

This paper is presented with the preceding, because there are several points of similarity between the two districts described. Both are near lines of country along which movements of upheaval were frequent during the time of formation of the Inferior Oolite rocks.

In the Bath–Doulting district, above the Upper *Trigonia* Grit which rests upon the Upper Lias over a restricted area, is the Dundry Freestone, and over a greater the Upper Coral Bed. Then come the

Doulting Beds. The Doulting Beds are equivalent to the *Clypeus* Grit of the district here dealt with; the Rubbly Beds to the Rubbly Beds, and the *Anabacia* Limestones, *plus* the Doulting Stone, to the 'Massive Beds' of the *Clypeus* Grit. The basal portion of the Fullers' Earth in the neighbourhood of Midford is of *zigzag* hemera. There is no reason for assigning the thin clay-bed, with its median band of *Ostrea acuminata* Limestone at Great Rissington, to any other hemera. Whatever is the case elsewhere, there is no deposit in the Rissington district between the *Clypeus* Grit and the Fullers' Earth.

3. "The Flora of the Inferior Oolite of Brora (Sutherland)." By Miss M. C. Stopes, D.Sc., Ph.D., Lecturer in the Victoria University of Manchester. (Communicated by Professor J. W. Judd, C.B., F.R.S., F.G.S.)

This paper is to place on record the discovery of a bed containing impressions of plants, which represent a flora bearing a strong likeness to that of the Inferior Oolite of the Yorkshire coast. Previously, but one species and a second doubtful one were known from these coal-bearing beds. The bed in which the plants were found was a thin shale-band cropping out below high-tide level on the coast, about 1¼ miles south of Brora. According to Professor Judd's mapping this reef would come within the boundary of the Lower Oolite, although from the more recent Geological Survey map it appears to come in the position of the Middle Oolite. It forms a band 2 or 3 inches thick in a barren grey shale, and the impressions are fragmentary except in the case of *Ginkgo*, some of the leaves of which are practically perfect and show the veining of the lamina, and in some cases (after suitable treatment) the minute detail of the epidermis. Seven species of plants are identified, one of them being new, and four other species admitting of generic identification; and most of these species are identical with those obtained from the Inferior Oolite of Yorkshire. The minute structure of the leaves of *Ginkgo* is compared with those of *G. biloba*, and proves the species to be quite distinct. The plants found are those of a land-area, probably with firm ground surrounding pools or shallow water, as indicated by the fact that *Ginkgo* and *Equisetites* are the two commonest forms.

4. "The Constitution of the Interior of the Earth as revealed by Earthquakes (*second communication*): Some New Light on the Origin of the Oceans." By Richard Dixon Oldham, F.G.S.

The attempts which have been made to account for the oceans and continents are all subject to an uncertainty, in that we have had no means of knowing whether it is a mere irregularity of form that has to be accounted for, or whether this irregularity is but the expression of a deep-seated difference in the constitution of the earth. The paper is an attempt to clear up this uncertainty by a comparison of the European records of the San Francisco and Colombian earthquakes of April 18th and January 31st, 1906. In the former case the wave-paths to Europe lay under the continent of North America and the continental shelf of the North Atlantic, being typically continental in character; in the latter case they crossed the broadest and deepest part of the Atlantic basin, being essentially oceanic. The absolute

rates of propagation cannot be compared, owing to the time of occurrence of the Colombian earthquake being unknown; but the interval between the arrival of the first and second phases is found to be longer in the case of this earthquake, by an amount much in excess of any probable error of record or interpretation. This difference indicates that the rate of propagation of the second-phase waves was relatively slower in the case of the Colombian earthquake, and, consequently, a difference in the constitution of the matter through which they were propagated. The Japanese records of the San Francisco earthquake also give an interval between the first and second phases which is greater than the average, the wave-paths in this case too being oceanic.

From these facts the general conclusion is drawn that oceans and continents are not mere surface irregularities of the earth's form, but are accompanied by, and probably related to, differences in the constitution of the earth beneath them, which extend to a depth of about one-quarter of the radius. It is not possible to state exactly in what this difference consists, beyond that it causes the rate of propagation of the second-phase waves to be less, in comparison with that of the first-phase waves, under the oceans than under the continents.

5. "The Swansea Earthquake of June 27th, 1906." By Charles Davison, Sc.D., F.G.S.

With the exception of the Hereford earthquake of 1896, the Swansea earthquake was the strongest which has been felt in this country for more than 20 years. It disturbed an area of 66,700 square miles, reaching from Rochdale on the north to Penzance on the south, and from beyond Maidenhead on the east to Waterford on the west. The centre of isoseismal 8 lies about 3 miles west of Swansea, the longer axis of the curve being directed E. 5° N. and W. 5° S. At Swansea, Neath, etc., the total number of chimneys thrown down or damaged must amount to several hundred.

The shock consisted of two distinct parts—the first part being much weaker than the second, except at places within an oval area lying some miles to the east of the Swansea epicentre. The existence of a secondary focus beneath this area is also indicated by the relative positions of the isoseismal lines, the isoseismal 8 being much nearer the isoseismal 7 at the western than at the eastern end. In twin earthquakes, it is difficult to ascertain the position of the focus in which the weaker impulse originated, but in the Swansea earthquake observations in mines offer an unexpected help. The shock was felt severely in mines within an area 8 or 9 miles in diameter, and as a tremor outside. The centre of this area lies about 1 mile west of Llwynypia, 22½ miles east of the Swansea epicentre, and is close to the centre of the area over which the weaker part of the shock was felt.

Observations, 53 in number, were obtained from 39 pits, distributed over an area 49 miles in length, from near Kidwelly to near Pontypool. The shock was, as usual, less strongly felt in pits than on the surface; and the sound was more uniform and monotonous, underground. Both shock and sound were observed in pits over about the same area. In pits not more than 5 miles from the nearest epicentre, the sound

seemed to pass below the workings; in those at a greater distance, it seemed as a rule to pass overhead or to travel along the workings. There is some, though not decisive, evidence for supposing that the fault was felt more severely in the lower than in the upper workings of a pit.

The originating fault in the neighbourhood of Swansea must run from E. 5° N. to W. 5° S., hading to the south, and passing not far from the line joining Llanelly to Neath, which is 5 or 6 miles to the north of the great east-and-west fault under Swansea Bay. The first movement occurred in the eastern focus near Llwynypia, and this was followed after a few seconds by a much stronger movement in the western or Swansea focus. The interval between the parts was such that the earlier impulse was felt first all over its disturbed area; but, as the foci were quite detached, the earthquake was no doubt a true twin earthquake.

6. "The Ochil Earthquakes of September, 1900, to April, 1907." By Charles Davison, Sc.D., F.G.S.

During this interval a series of slight shocks was felt chiefly in the villages of Blairlogie, Menstrie, Alva, and Tillicoultry, lying between the Ochil Hills and the river Forth. There were four shocks in 1900, one in 1903, ten in 1905, nineteen in 1906, and eight up to the end of April, 1907. The strongest shock of the series occurred on September 21st, 1905; its intensity was 6, and it disturbed an area of about 1,000 square miles. The originating fault must be directed from about E. 27° N. and W. 27° S., hading to the north, and passing not far from the villages mentioned above. It cannot, therefore, be identified with the great Ochil Fault, which in the district referred to runs from about E. 15° N. to W. 15° S. and near Dollar hades to the south; although it is possible that some or many of the slighter shocks may have been due to slips along this fault.

It was announced that "The History of the Geological Society of London," by Horace B. Woodward, F.R.S., illustrated with twenty-eight portraits and reproductions of medals, will shortly be obtainable at the Society's Apartments, price 7*s.* 6*d.* nett; and at the reduced price of 6*s.* by Fellows only.

The next Ordinary Evening Meeting of the Society will be held on Wednesday, November 6th, 1907.

III.—Mineralogical Society.

Tuesday, June 11th.—Professor H. A. Miers, F.R.S., President, in the Chair.

Hamlinite from the Binnenthal, by Mr. H. L. Bowman. A mineral occurring in small brown six-sided plates in the white dolomite, to which the name bowmanite was given by Mr. Solly in 1904, is shown by analysis to be identical with hamlinite. The crystals show a division into six biaxial sectors, and are consequently pseudohexagonal.—Faceted Beads of Zinc, by Mr. T. V. Barker. The President described beads of zinc deposited on crucible lids by sublimation of zinc through oxide of tin. Some of these beads are covered with brilliant facets

and present the appearance of crystals rich in faces. Mr. Barker has found that they do not lie in zones or obey the laws of distribution of ordinary crystal faces, and cannot therefore be regarded as the faces of a single crystal. There is, however, no evidence, from etching by acid, that the bead is an aggregate of crystals. The nature of these remarkable faces is difficult to understand. A bead of platinum presenting the same peculiarities was measured by the late Professor Miller. — Chlormanganokalite, by Dr. H. J. Johnston-Lavis and Mr. L. J. Spencer. A preliminary account of this new Vesuvian mineral was given by Dr. Johnston-Lavis in *Nature* on May 31, 1906. A new analysis of the mineral gives the formula $MnCl_2 \cdot 4\,KCl$. The crystals are rhombohedral, with a rhombohedral angle of 57° 36′; they are optically uniaxial with very weak positive birefringence; the refractive index is 1·59 and the specific gravity 2·31.—Mr. L. J. Spencer exhibited a suite of beautifully crystallized minerals, presented to the British Museum by Mr. Percy C. Tarbutt, from the Rhodesia Broken Hill mines in North-Western Rhodesia. In driving a tunnel through one of the kopjes, which consist mainly of cerussite and hemimorphite, a cavern containing flint implements and bones of recent mammals was encountered, and a cavity in the bone-breccia on the floor of this cave was encrusted with magnificent groups of hopeite crystals (the rare hydrous zinc phosphate discovered by Sir David Brewster in 1823). In the vicinity of the cave, crystals of another hydrous zinc phosphate were found in association with descloizite (hydrous vanadate of lead and zinc). The crystals of this new species, for which the name *tarbuttite* is proposed, are anorthic; they possess a perfect cleavage in one direction, through which emerges obliquely the acute negative bisectrix of the optic axes. Cavities in the ordinary ore are lined with large twinned crystals of water-clear cerussite, which are encrusted with small crystals of hemimorphite.—A group of quartz-crystals from British Guiana was exhibited by Mr. Anderson and a fine crystal of apatite by Mr. Gordon.

CORRESPONDENCE.

CHEMICAL REACTIONS BETWEEN SOLIDS.

Sir,—The attention of geologists should be drawn, I think, to some recent experiments by Mr. E. P. Perman, briefly described in *Nature* for June 20th last, in the abstracts of the Proceedings of the Royal Society; and of which further details will no doubt soon be available. The author finds that reactions take place between many pairs of salts in the solid state, but he also finds that careful drying prevents such reactions. From this he concludes that the reactions are carried on by means of thin films of water, acting as ionizing solvents. Many salts react on merely shaking their powders together; but all the changes are greatly aided and accelerated by heat and by pressure.

The importance of these experiments for geologists will be obvious enough, and needs no insisting upon, particularly in connection with metamorphic problems. Indeed, geologists might claim a sort of priority, for Mr. Perman's "Heat, Pressure, and Water" have been allies of ours for many years past. Not that this detracts from the

value of such work to us. It is just such work that we need, to put our ideas into more distinct and scientific forms; and modern chemistry will evidently do this service more rapidly than we could have hoped. Mr. Perman's salts were no doubt more tractable than those that are the components of rocks, but then it is quite certain that his agencies have been applied to rocks fully in proportion to the refractoriness of their materials. And Adams's experiments upon the flow of marble show that some rocks, at any rate, are not beyond the power of laboratory treatment.

In this Magazine for May, 1903, I attempted to apply the work of Roberts-Austen on the Diffusion of Metals to the Diffusion of Granite into Crystalline Schists, and, at the close of my paper, I dwelt on difficulties arising from the heterogeneity of the materials of rocks. But it is clear that chemical reaction between solids adds vastly to the possibilities of solid diffusion unaided by such changes, and a hope of further information of the kind is expressed in the concluding paragraph of the paper quoted.

Geologists will look forward with interest to the full text of Mr. Perman's paper, and hope that he will pursue these researches further still.

EDWARD GREENLY.

OBITUARY.

JOHN FRANCIS WALKER, M.A., F.L.S., F.I.C., F.C.S., F.G.S.

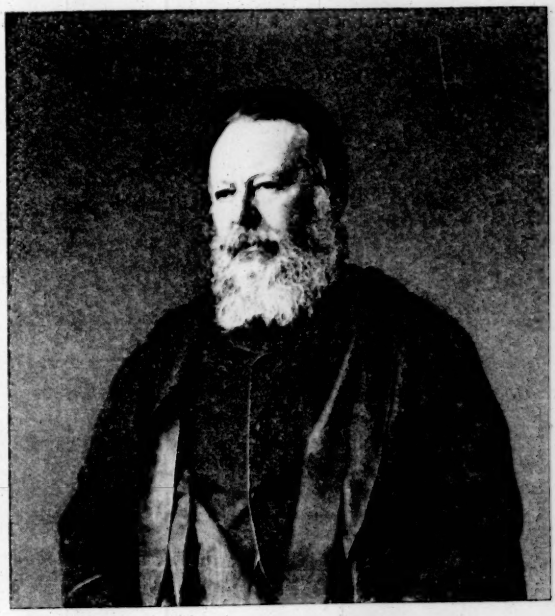
FORMERLY FELLOW OF SIDNEY SUSSEX COLLEGE, CAMBRIDGE.

WITH A PORTRAIT, PLATE XVI.

BORN NOV. 25, 1839. DIED MAY 23, 1907.

ALL lovers of Yorkshire may well feel proud of the many eminent geologists who either claim it as their birthplace, or have adopted this grand county, so rich in geological and palæontological interests, as their home. One recalls to mind the names of some belonging to the past and some still present with us: Young and Bird, Dr. Wm. Smith, the Williamsons, Martin Simpson, W. Vernon Harcourt, John Phillips, Dr. H. C. Sorby, Dr. Murray, J. Leckenby, Sir Charles Strickland, Dr. John Lycett, Rev. Professor J. F. Blake, W. H. Hudleston, Dr. Reed of York, Professor L. C. Miall, Ralph Tate, Jas. Wm. Davis of Halifax, Dr. Tempest Anderson, Samuel Chadwick, G. W. Lamplugh and many others. To those worthies whose names are inscribed upon her past records, must also now be added that of John Francis Walker.

Born at York, Nov. 25th, 1839, J. F. Walker was, by inheritance, a Freeman of that city, where his family had resided for several generations, his grandfather having held the office of Sheriff in 1814. At an early age he commenced his education at St. Peter's School, York, and at 18 he became a student at the Royal Agricultural College, Cirencester, where under Dr. Voelcker, F.R.S., Professor of Chemistry, and Professor James Buckman, F.G.S., Professor of Natural History, he imbibed that earnest love of chemistry and geology which had such an important influence on his future career in life. In 1862 he entered Sidney Sussex College, Cambridge, and was bracketed first in the Natural Science Tripos in 1866. From Cambridge, after taking



J. J. Thomson

his degree, Mr. Walker proceeded to the University of Bonn, where he studied organic chemistry under Professor Keckule, and remained in Germany during the Franco-Prussian War. Returning to London, John Francis Walker studied Law, and was in due course called to the Bar, but never practised.

He subsequently returned to Cambridge as Chemical Lecturer, and was elected to a Fellowship in Sidney Sussex College, where he had formerly been a student. But even his love for chemistry was in time entirely overshadowed by his stronger attachment to geology.

In 1867 he was elected a Fellow of the Geological Society, and in 1873 of the Linnean Society. About this time he also became a Fellow of the Chemical Society, and a member of the Geologists' Association.

J. F. Walker took the deepest interest in collecting the fossils from the Lower Greensand of Cambridgeshire, known generally as the "Coprolite Workings," and on May 7th, 1867, he communicated his first paper to the Yorkshire Philosophical Society on "Some new Coprolite Workings in the Fens" (Geol. Mag., Vol. IV, p. 309), and later on in the same year another paper, "On some New Terebratulidæ from Upware" (Geol. Mag., Vol. IV, p. 454, Pl. XIX).

In 1882 Mr. Walker married Miss Alice Cracknell, of Knowle House, Ealing, W., and afterwards retiring from Cambridge he settled at 45, Bootham, York, devoting the greater part of his time to his geological pursuits.

During his residence in York, for the last 25 years, John Francis Walker has taken the deepest interest in the prosperity of the Yorkshire Philosophical Society's Museum, and has been for some time past its senior Vice-President and Honorary Curator of its Geological Collection, to which he has also been a most liberal donor.

He presented the types of his Cambridge Greensand Brachiopoda to the British Museum, and those illustrating his joint paper with Mr. G. W. Lamplugh, "On the Brachiopoda from the Lower Greensand of Leighton Buzzard, Bedfordshire," to the Geological Society's Museum.

Mr. S. S. Buckman, F.G.S., writes to the Editor:—"The loss of our friend and fellow-worker in geology, John Francis Walker, will be keenly regretted by all who are interested in the study of Brachiopoda. They will miss a genial friend who was ever ready with kind sympathy and practical help. He had accumulated a splendid collection of British and foreign Brachiopoda; and he would place his knowledge and his specimens at the disposal of other students with the greatest generosity. Many anecdotes are told of his readiness to help. If an investigator wished to examine certain specimens from a Yorkshire locality and Mr. Walker had not a sufficiently good series, he would take the trouble to make a special visit to the locality in order to obtain the necessary material. Or a student wishing to compare some foreign species with its British allies, made application to Mr. Walker. If he possessed specimens they were placed at the student's disposal; but on occasions when he had not any examples he has sent to the Continent to purchase them, and has desired the student to keep one of the best for his own

collection. Spontaneously, too, he enriched many a cabinet. A box of specimens would arrive with a kindly note to say that he had obtained an interesting series from some locality, and he hoped his correspondent would find the enclosed specimens an addition to his series.

"Although Mr. Walker collected Brachiopoda of all ages and all countries, he perhaps paid most attention to British Jurassic species. He was the first to find the rare *Dictyothyris* [*Terebratula*]-*Morieri* in England, and one of his earliest papers gave an account of the discovery. For many years he spent some portion of the Summer on the Dorset coast to work the rich deposits in the neighbourhood of Bridport; and he published some papers on his discoveries in this district. He also made sojourns in the Cotteswolds; while at other times his hammer was busy among the rocks of Yorkshire. Only last Summer he made a collecting tour among the Jurassic rocks of the Normandy coast, and several of his friends' cabinets are the richer for specimens which he then obtained. All who have had the good fortune to join Mr. Walker in his geological excursions will feel the keenest regret that they will no more hear his cheery voice, or be able to share his great enthusiasm over the discovery of some fine specimen."

One of his most attached Yorkshire friends, Mr. G. W. Lamplugh, F.R.S., writes:—"Placidly and unobtrusively, he stood aside to let the turmoil pass him, and only those who were privileged long to enjoy his friendship—to be among whom I count myself fortunate—could appreciate the depth of his knowledge and of his kindliness.

"In his palæontological studies his aim was toward an ideal thoroughness that perhaps is unattainable, and he was always content—even, as it seemed to me, too content—to wait for conditions that should approach his ideal. Thus, much work of excellent purport that he contemplated, and might have done well, because it could not be done perfectly remained undone to the end. Although his collection of the Mesozoic Brachiopoda—his favourite and lifelong study—was probably the most extensive that has ever been made, his saying was always—'We want more material! We must wait till we have sufficient material!' And it was his philosophical grasp of the broader problems of his subject that led him to this attitude, and not merely the spirit of the collector. The fundamental principle of his method found expression in his favourite dictum: 'It would be good for palæontology if all type-specimens should be destroyed!'—and most workers who have striven to follow the recent developments of palæontological science will apprehend the truth that underlies this paradox. Walker, firmly holding the evolutionary idea to which his work had led him, recognized that 'the true type of a species is its centre, where the individuals are most thickly clustered and most closely resemble each other,' and that 'a named figured specimen is only a fixed point' which may, or may not, happen to be near or within the central cluster of the species. Hence he said, no single individual can adequately represent a species, and the so-called species based on type-specimens are of unequal value and often misleading.

"These ideas were expressed baldly and without specific demonstration in his brief paper 'On the Formation of a Species,' published in the Geological Magazine for January, 1905 (Dec. V, Vol. II, pp. 15–17); but no one unacquainted with the worker can have guessed from it how huge was the store of exact observation that underlay this apparently sporadic expression of opinion.

"Walker's quiet enthusiasm in a task that appealed to him was well exemplified by the manner in which he followed up the discovery of a fossiliferous band rich in Brachiopoda at the top of the Lower Greensand near Leighton Buzzard, which enlisted his attention five years ago. During two successive summers he spent many days on the spot, accumulating material and educating the workpeople in the collection of specimens. Not only the quarrymen but also the children of the quarrymen became his willing helpers, and will long remember his kind and generous presence among them. His aim was to acquire the whole of the Brachiopoda that could be obtained from the limited nodular band that yielded the fossils, with the idea that it would give him the opportunity at last for amassing sufficient material to deal adequately with the question of 'species' and their relation to 'varieties.' Some preliminary results of his work were published, not very willingly on his part, in our joint paper in the Quarterly Journal of the Geological Society for May, 1903 (vol. lix, pp. 234–265, pls. xvi–xviii), based on a collection that would have been already too large for the patience of most palæontologists, though the refrain to his specific descriptions in this paper is still 'the want of further material.' His subsequent accumulation of the specimens went steadily on, until he could number them by hundreds or thousands, all laboriously cleaned, measured, and sorted, into their proper specific relationship, ready for the final work to be done. And, a short time ago, when I wrote to tell him that a recent visit to the section led me to think that the calcareous lenticles had been practically all removed in quarrying, so that he must not hope for a fuller series of the fossils, he replied cheerily that this could not be quite so, as he had just received a fresh parcel from the quarrymen that added to our knowledge.

"But now, by the sad event of his short illness and untimely death, we are reminded once more that no single life is long enough for the completion of such work, and that fragmentary instalments alone are possible to us. For the task unfinished there is indeed in his case this slight consolation, that the concrete material which he so patiently collected and brought into order lies ready for the future student to take up the arrested work. So that not only by what he himself achieved, but also by the achievement that he has made possible for the workers who will follow him, the name of John Francis Walker will be remembered and honoured.

"The loss to palæontological science is severe. But still more severe is the loss, to us who knew him, of an ever-genial, broad-minded, big-hearted friend."

Mr. Lindsall Richardson writes to the Editor:—"To geologists like myself Mr. Walker was chiefly known as a keen Brachiopodist. The writings of the late Dr. Thomas Davidson, F.R.S., in the Palæontographical Society's volumes, show that he was in frequent